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SCIENCE

20 March 1959

Volume 129, Number 33

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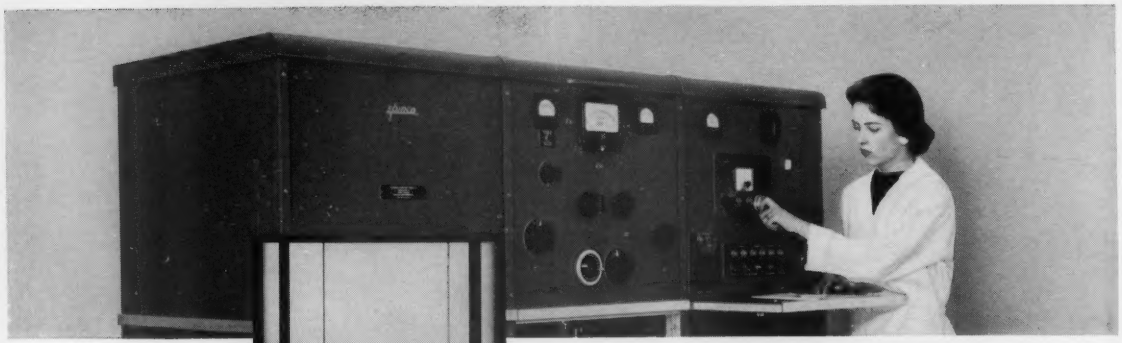
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

New Methods Extend the Usefulness of the Ultracentrifuge

Recent studies by research scientists have further increased the uses of the Analytical Ultracentrifuge for measuring molecular weights and purity of viruses, enzymes, proteins, polymers and a variety of organic and inorganic molecules. Here are four new developments as reported in the technical literature.



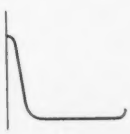
Interacting Systems

Kegeles and Rao at Clark University have measured the molecular weights of chemically reacting systems in the ultracentrifuge cell using the Archibald "approach-to-equilibrium" method. Studying the enzyme system alpha-chymotrypsin, they showed it to be present in the ultracentrifuge cell as an equilibrium mixture of monomers, dimers, and trimers. This is an extension of previous work which showed that the Archibald method applies to polydisperse non-ideal solutions, as well as to monodisperse ideal solutions.

Improved Accuracy

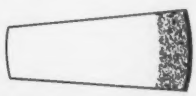
Trautman, at New York's Rockefeller Institute for Medical Research, showed that the accuracy of the Archibald method can be improved by more precisely locating the position of the meniscus on the ultracentrifuge photographic plate. He made a detailed study of the optical fine structure at the meniscus, and used a special optical aligning procedure with a mirror in the ultracentrifuge cell.

Simplified Measurements

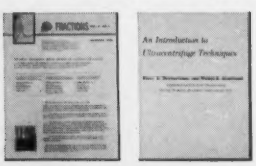


At Stockholm's Nobel Medical Institute, Ehrenberg reports a simplified approach-to-equilibrium method which makes measurements from the schlieren curve easier. He runs the ultracentrifuge fast enough for a peak to begin forming at the meniscus so that the schlieren curve is parallel with the baseline and no extrapolation is necessary. His measurements of molecular weight and diffusion constants agree closely with those by other methods.

Rapid Equilibrium



Van Holde and Baldwin at the University of Wisconsin have used short liquid columns to achieve complete sedimentation equilibrium in a fraction of the time previously required. Using liquid columns of only 3 mm, they report equilibrium with sucrose in 3½ hours, and with a 1 mm column in only 30 minutes. In addition, the authors report that measurements during approach-to-equilibrium permit calculation of a diffusion coefficient.



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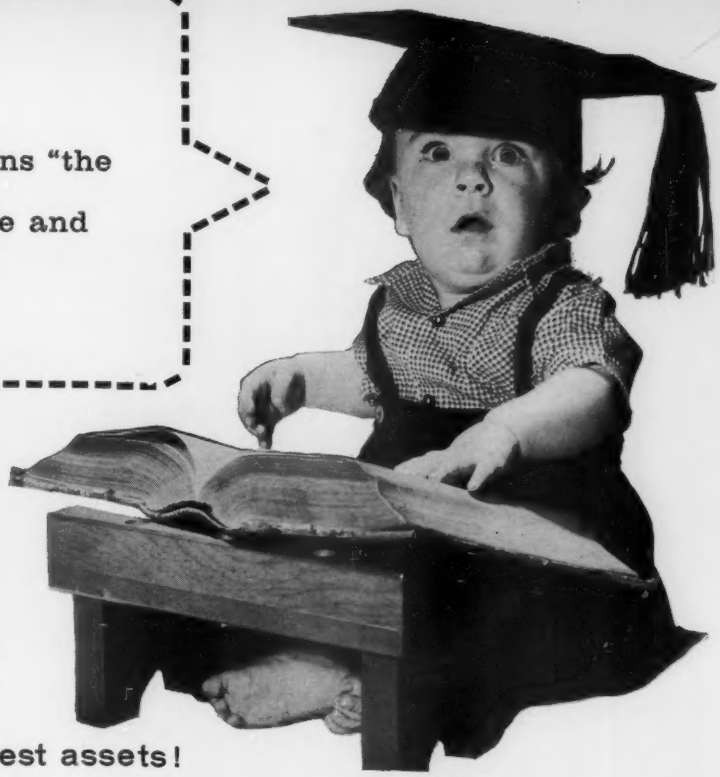

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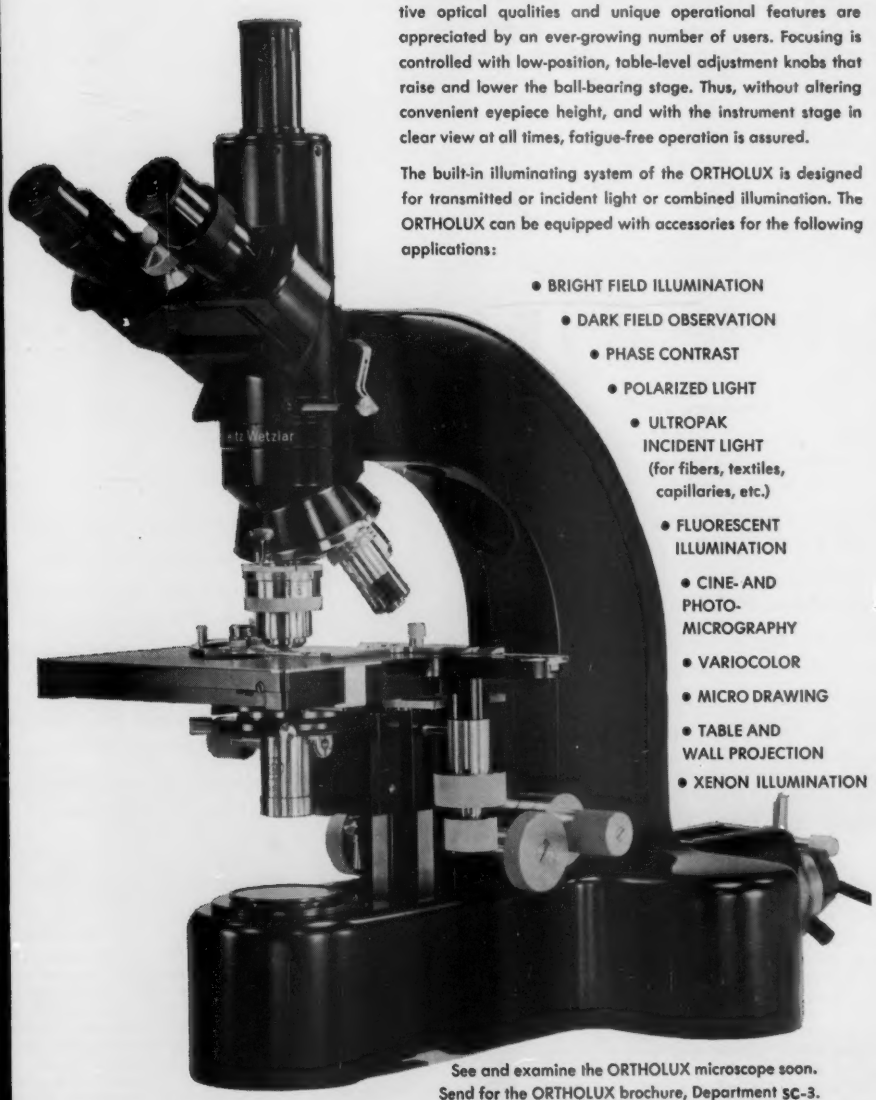

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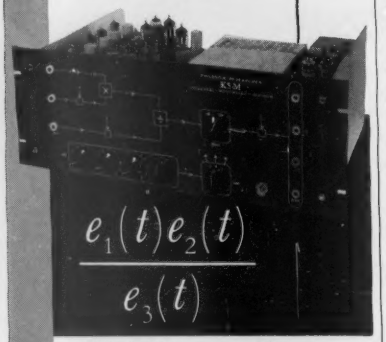

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Letters

Education of Science Teachers

The letter from William W. Porter II [*Science* **128**, 1156 (1958)] is an excellent illustration of how to promote resistance to the ideas one advocates. Educationists are told that their courses are completely worthless. Since they continue to offer these courses and even urge students to take them, it follows that either they are stupid or they are hypocrites. Neither of these accusations is, of course, uncommon.

Furthermore, we are asked to treat with respect arguments such as, "the world's great teachers, from Buddha, Aristotle, and Jesus Christ down to include most of our finest contemporary teachers, never had *any* courses in an education department." I cannot seem to recall exactly what university courses Buddha, Aristotle, and Jesus Christ *did* take and therefore cannot adequately evaluate the implied recommendation that public-school teachers prepare themselves in a similar fashion. However, with an ignorance of the facts which I suspect is equal to Porter's, I can assert that he is wrong about the contemporary group. I can maintain that most of our finest contemporary teachers have taken education courses and are teaching in our public schools, unrecognized and unrewarded.

It is stated that the President's science adviser is barred from teaching in the public schools. This is not strictly accurate. Most states offer provisional certification, and few, if any, school districts would turn down Killian if he would but apply. It may be noted that "mere money and salary increases" are almost certainly necessary, albeit not sufficient, conditions for an increase in the number of high-school teachers that are of this caliber.

Again, Porter seems to overlook the fact that the student receiving a general secondary teaching certificate from the University of California, to take his example, has (i) completed an undergraduate major in his subject field, (ii) been recommended by the department concerned, (iii) spent two semesters as a graduate student, and (iv) taken, as a rule, only 17 to 19 hours of education courses, which is only slightly more than one of his ten semesters of work. If his liberal arts background is deficient, perhaps the liberal arts departments need investigation.

The summer-school situation is typical of many universities and occurs for a variety of reasons. Among them may be noted: (i) the feeling among considerable numbers of teachers that they will learn more in education courses than in other courses; (ii) the relative rarity of liberal arts (especially science) courses appropriate for high-school teachers who have already completed undergraduate majors but who do not have the time, interest, or ability to undertake courses designed for prospective research workers; (iii) the suspicion among the students, not entirely unfounded, that if they take courses other than those in education, their interests and problems will be ignored and they may have to listen to sneers at themselves, their colleagues, and their profession. The frequency with which they encounter this attitude during the regular sessions is sufficient to dissuade a number of potentially able teachers from entering the profession each year.

It should be noted that the major premise of the educationists has been conceded by Porter, by the many others who have written similar letters and articles, and by those who attended the AAAS Parliament of Science. Obviously, we all agree that the problems of education need lengthy, serious, and mature consideration. It follows that teachers in training as well as those not as directly involved in public education should spend some time on this task.

Up to this point I have been, almost willy-nilly, reacting against the statements in Porter's letter. In so doing I have made statements almost as contentious and unfair as those against which I have railed. The sad thing about all this is that there is much truth in Porter's indictment. For example, almost all the educationists I know agree that certification requirements are sometimes arbitrary, rigid, and excessive. Also, the active participation of all departments of the university in teacher education has been fervently sought for years by many educationists. It appears that in several fields, notably mathematics, progress is being made. Finally, many of us agree that political action will be necessary, since, unfortunately, our influence is actually small. In short, there is enough agreement so that we *could* work together.

I would say to all who feel as Porter does (a majority of those at the Parliament of Science, it seemed to me) that we, the educationists, are glad that you are becoming seriously concerned about the public schools. Constructive, forward-looking criticism, suggestions, and, above all, participation in action are welcomed by us. You will find that most of us agree with you about the necessity for a thorough liberal arts preparation for teachers. You will disagree with us about the necessity for education courses. However, if you are willing to put in sufficient time and effort, you may well become convinced that the tremendous amount of study and research we have done in psychology and education in the past 50 years has produced a body of

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knowledge with which teachers should have some acquaintance. After due consideration, you might even concede that there are some things that teachers should know as members of an important profession, as public employees, and as part of one of the most important of all American institutions.

DONALD ROSS GREEN

Division of Teacher Education, Emory University, Atlanta, Georgia

I find that I must disagree most thoroughly with Porter on every point that he makes concerning the education of science teachers for the secondary schools. He makes statements which are either patently false or are not applicable to the situation. However, these arguments of his (which are not new) are not my present concern.

From my experience in three institutions which train science teachers and carry on in-service programs to upgrade the quality of teachers, I find a number of factors at work which make teacher training less adequate than it should be.

The first of these factors has to do with the manner in which liberal arts and graduate science courses are taught. Demonstration and other illustrative materials are prepared out of sight of the student. The source of teaching films and other audiovisual materials is not revealed. As a result, the student, while he learns the content, does not have an opportunity to learn how to teach this same material. Some instructors, in fact, seem to regard the precise method of preparing a particularly effective demonstration as a professional secret to be kept from the students.

A second point of considerable difficulty has to do with the scheduling of content courses. While schools of education typically offer a number of courses in the late afternoon, on Saturday, and in the evening for the convenience of teachers, such courses on the level desired in the subject areas are seldom encountered. The same problem occurs for students when they are practice-teaching. The lecture-laboratory pattern of most science courses, coupled with the problems of transportation that student teachers encounter, serves to keep them from taking content courses. As to summer-session courses, I would like to suggest to Porter that it is hardly reasonable to compare the offering of the entire education department to that of only a few content areas. I must assume that history, economics, sociology, English, literature, and foreign languages, to name a few, were also taught at the University of California at Los Angeles in the summer of 1958. I am certain that science and mathematics teachers were but a minority of those enrolled in the university last summer and that the number of education courses was not, in fact, disproportionate.

In closing I would like to suggest to Porter and others who feel as he does that they observe student teachers in the schools and see for themselves what the problems and deficiencies of the beginning teachers are. They will find their educationist colleagues eager to help them visit the schools.

PETER DEAN

Wayne State University, Detroit, Michigan

Porter's complaint, in general, is that a college graduate with a major in science cannot begin to teach at once.

Neither can a young man with a major in—let us say—chemistry begin practice as a physician or a dentist, be admitted to the bar, get a license to preach, set up an architectural or engineering office, join the musicians' union, or solicit clients as a public accountant.

Neither can a young woman with a major in—let us say—biology register as a nurse for hospital or private practice, apply for a dietician's post, or even open a beauty shop.

These young people are specialists, but they are not professionals. Professions, of which teaching is one, require certification to protect the public from amateurs and the untrained.

The reason there are so many different courses in education (as Porter counts them in a certain institution) is that there are so many different kinds of teachers. An elementary teacher (kindergarten through third grade) needs specific information and experiences which are different from those helpful to an intermediate teacher (fourth through sixth grades). Teaching at junior and at senior high-school levels involves by no means the same topics, texts, or techniques. Therefore certain fundamental courses are given first, then, in the department of education, specialization begins, just as in a medical school. Of greatest value before graduation are the many weeks of practice teaching required, analogous to the medical student's bedside courses and actual hospital experiences.

Porter's letter is another among the hundreds of published objections to the professional education of teachers which date back to 1839, when the first normal school was established, at Lexington, Mass., with 25 young women as students. The eloquence of Horace Mann outweighed the opposition before the Massachusetts legislature at that time. The professional training of teachers has its opponents, and also its defenders, today.

HANOR A. WEBB

245 Blue Hills Drive, Nashville, Tennessee

(Continued on page 786)

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20 March 1959, Volume 129, Number 3351

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Science for the Misses

One of the conclusions reached by James B. Conant in his recent report on American high schools is that academically talented girls are not receiving satisfactory guidance. Studying in detail a group of 22 better-than-average high schools, Conant found that in most of the schools a majority of the academically talented boys are taking at least seven years of science and mathematics during four high-school years, while in none of the schools are a majority of the more able girls taking seven years of science and mathematics. From some viewpoints the guidance at present offered able girls in the schools should be changed, but from the viewpoint of women now seeking full, constructive lives as scientists, engineers, or mathematicians, the present guidance makes sense.

To discourage girls from going into science may be realistic because, as observers note, women are discriminated against in this field. They have less chance than men of being employed at their full potential, and they are employed at lower salaries. The attitude in the schools reflects the attitude in the adult world. Only boys and men may profitably study mechanical things and scientific ideas; girls and women will find them too difficult. Or, to put the general consensus even more briefly, men are better than women.

Whatever the present attitudes, the battle of the sexes is not yet over. Improvement in opportunities for girls who become scientists, engineers, or mathematicians may occur, perforce, because of increases in the demand for specialized talent. There is every expectation that excellence in science will play an increasingly important role in the contest between East and West as well as in our expanding civilian economy. As to how this country now stands in relation to the Soviet Union, a number of observers have compared unfavorably our present use of able women with theirs, particularly in engineering and medicine.

To seek a change in those attitudes that put a limit on the achievements of women over and above the limit set by abilities is not to forget that girls become women and women get married and raise children. The employment of women does raise problems not raised by the employment of men. More liberal personnel policies may be necessary, especially as they bear on leaves of absence, part-time schedules, and travel requirements. But if life becomes a little less convenient for the employer, in a field like that of research it can still be readily managed.

On the question of men, women, and careers, we must confess that we have our prejudices, too. We like to see talent encouraged whether it is possessed by a boy or a girl, and whether the talent is in science or in some other field of endeavor. That the employment of more women is part of the answer to growing demands for technological manpower seems to us clearly proved, but we see a manpower shortage less as a reason for employing women in science than as a good argument for putting able women where they should be in any case. Increases in demand for specialized talent may be just the thing to stop the cycle in which the lack of education of able women means poor opportunities, and poor opportunities mean less motivation to seek more education.—J.T.

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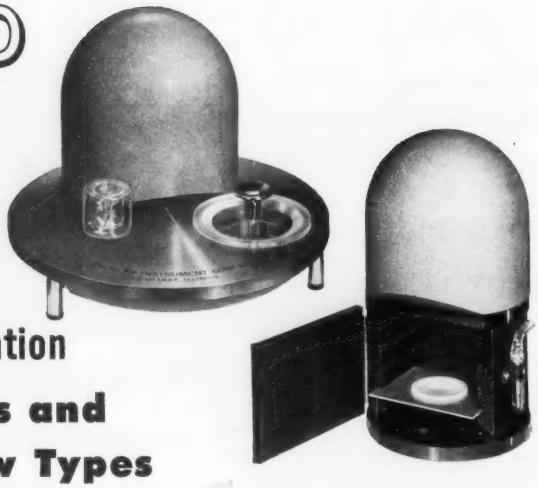

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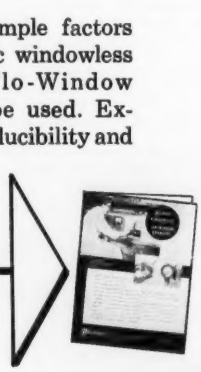

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20 March 1959, Volume 129, Number 3351 SCIENCE

Radar Echoes from Venus

Advances in several arts made possible this experiment in radio astronomy performed during the IGY.

R. Price, P. E. Green, Jr., T. J. Goblick, Jr., R. H. Kingston, L. G. Kraft, Jr., G. H. Pettengill, R. Silver, W. B. Smith

The possibility of obtaining radar echoes from celestial bodies outside the Earth-Moon neighborhood, and the scientific value of information obtainable from such echoes, has been discussed by Kerr (*1*) and others (*2*). The attainment of such objectives has been brought from the realm of theoretical interest to within the range of experimental accomplishment with the advent of (i) receiving amplifiers having low noise, such as the maser, (ii) high-power missile-tracking radar transmitters employing steerable antennas of large aperture, and (iii) flexible and stable digital data-processing techniques.

On 10 and 12 Feb. 1958, about 2 weeks after Venus' closest approach, signals from M.I.T. Lincoln Laboratory's Millstone Hill radar installation (*2a*) were directed toward Venus. That planet was then about 28 million statute miles from the Earth, and the time required for radar signals to reach Venus and return was about 5 minutes. The equipment was operated with the characteristics shown in Table 1. With these specifications, it should be possible to detect the planet near its time of closest approach to the Earth, provided that the planet is a good reflector at 440 megacycles per second and that the reflection is reasonably coherent over the pulse length. Under such conditions, a signal-to-noise ratio of −10 decibels should be obtained at the output of a filter matched to a single received pulse when Venus is at a distance of 28 million miles. By repeated pulsing of the transmitter and proper integration of the received signal over several thousand pulses, a signal-to-noise ratio can be built up that is sufficient to establish the presence of the return unequivocally.

The authors are members of the staff of Lincoln Laboratory, Massachusetts Institute of Technology, Lexington.

Data Collection and Processing

Five separate runs were made, and data from four of these have been processed. In each run signals were transmitted for approximately 4.5 minutes; the transmitter was then turned off, and the receiver output was recorded on magnetic tape for the following 5 minutes.

Because of the uncertainty in the size of the solar system, which is several times the normal interpulse period employed (33.3 milliseconds), it was decided to code the transmission in such a way that range ambiguities could be resolved. For this purpose, the normal stream of transmitted pulses occurring 33.3 milliseconds apart was gated on and off by a binary maximal-length shift-register sequence (*3*). The transmitted waveform then had the appearance of a periodic train of 2-millisecond pulses, except that half of them were deleted in a pseudo-random fashion.

The transmitter used a high-power klystron, and the stability of the entire transmitter-receiver conversion chain held to within 1 cycle per second during the 10-minute period of each run. A three-level, solid-state maser (*4*) with a potassium (chromi) cobalticyanide crystal in a bath of liquid helium was employed with a directional coupler to provide the low-noise receiving front end.

In receiving, a spectral zone 3 kilocycles per second wide, centered roughly 20 kilocycles below the transmitted carrier in order to pass the Doppler-shifted radar return, was accurately converted down to an intermediate frequency lying in the audio region. After the amplitude of this signal was quantized into 64 levels by means of an analog-to-digital converter operating at a sampling rate of 12 kilocycles per second (crystal-controlled), the signal was recorded on magnetic tape in a format suitable for later processing by an IBM Type 704 electronic digital computer.

In processing, the recorded data are first passed through the digital equivalent of a matched filter whose impulse response is a sinusoidal pulse 2 milliseconds long. The frequency of the sinusoid is deduced from the expected Doppler due to Earth-Venus motion and Earth rotation, together with the known receiver conversion frequencies. The envelope of the filter output is then squared and cross-correlated against a replica of the transmitted envelope; proper compensation is made for the Doppler shift in the pulse repetition frequency caused by the receding motion of the planet. Cross-correlations were taken at 1-millisecond increments in the relative delay between the reference and the squared filter output, until a region of uncertainty of approximately 600 milliseconds had been completely explored.

Results

Of the four runs that have been processed, two show no evidence of radar returns. Each of the other two, however, exhibits in its cross-correlation function statistically significant evidence of a return, as is shown in Fig. 1. Figure 1 shows that portion of each of the final

cross-correlation records lying in the neighborhood of the largest signal peaks. The records of the two days have been drawn with the central peaks aligned. The bottom curve shows the correlation function that would be expected for the type of modulation employed if noise were absent. The correlation curve consists of a periodic series of peaks of uniform height except for a single peak of double amplitude at the target range.

For clarity's sake, Fig. 1 shows a region of only ±50 milliseconds about the center (that is, roughly ±2 parts in 10^4 out of a round-trip travel time of 300 seconds). Our cross-correlation results actually extend over a much larger range of ±1 part in 10^3, and the part not shown here looks much like a continuation of Fig. 1. That is, for the run of 10 February, throughout the larger region (except where the periodic half-height peaks are expected) all points are more than 1.3 standard deviations below the central peak of Fig. 1. For 12 February the figure is 1.9 standard deviations. At the points where half-height peaks are expected, the figures are 0.6 and 1.1 standard deviations for 10 and 12 February, respectively.

In addition to the evidence in each curve separately, there is the persuasive fact that the measured change in round-trip travel time between the two successful runs differs by only 2.2 milliseconds (about 200 miles), or about a pulse width, from the predicted value of 7.4755 seconds. Much of the slight discrepancy can be accounted for by round-off error in the astronomical tables (*5*), where daily Earth-Venus distances at close approach are tabulated to only six figures, or about 1 millisecond of accuracy. (Correction was made for effective center-to-surface distances (*6*) of the two planets.) It is also likely that noise has produced small displacements in the correlation peaks.

The round trip travel times deduced from the two peaks are 295.5065 ± .0005 seconds for 10 February and 302.9842 ± .0005 seconds for 12 February. Each of these travel times is that of the first transmitted pulse, which occurred at 14:21:05 E.S.T. on 10 February and 12:00:55 E.S.T. on 12 February. Preliminary calculations from the ephemeris (*5*) predict the delays shown by the heavy arrows in Fig. 1, and these values of delay were used as the starting points in searching for the signal peak. The calculation from the ephemeris used a velocity of light of 299,860 kilometers per second and, correspondingly, a distance scale of 498.580 seconds per astronomical unit (the mean radius of the earth's orbit.) If the velocity of light is assumed to be correct, then our result implies that the astronomical unit is about 0.0013 percent smaller than the value given in the ephemeris (*5*). On the other hand, the detailed optical analysis of the orbit of Eros performed by Rabe (*7*) indicates that the astronomical unit should be (0.018 ± .004) percent larger. Future radar observations, it is hoped, will resolve this disagreement.

A detailed statistical examination has

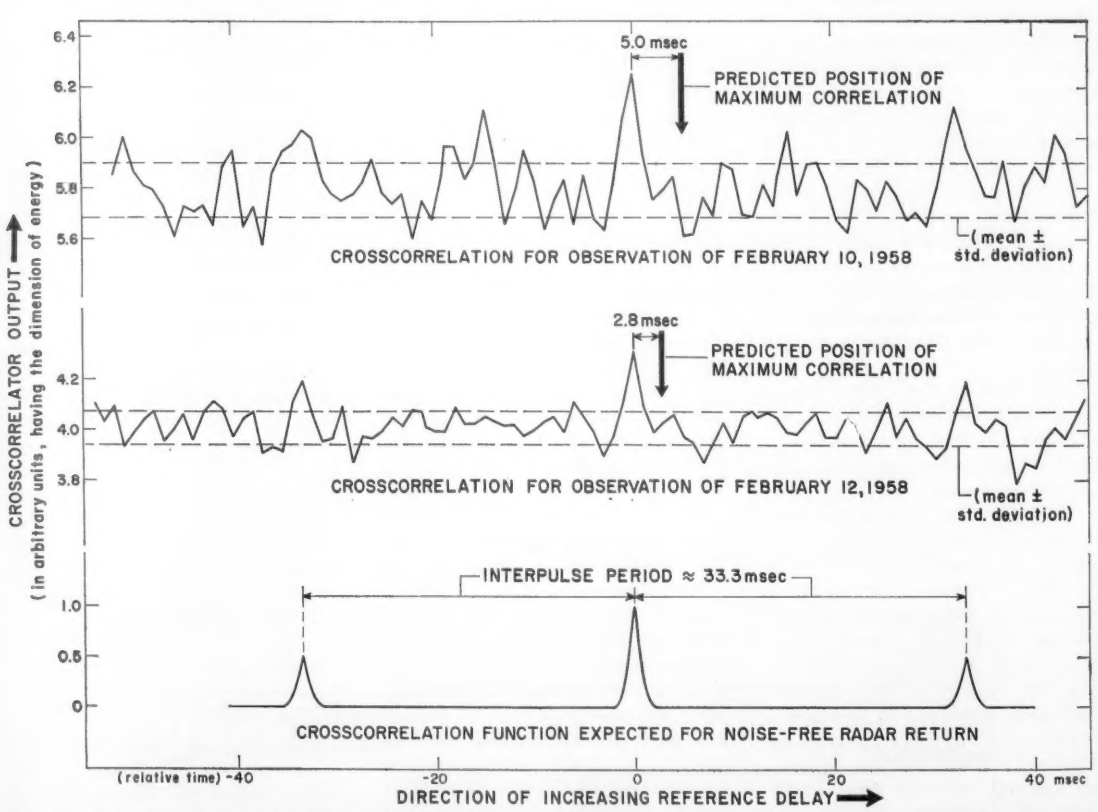

Fig. 1. Results of processing the signals received from the direction of Venus on 10 and 12 February 1958. On 10 February the predicted round-trip travel time for the first pulse was 295.5115 seconds, and the predicted signal-to-noise ratio after processing was 10.4 db. On 12 February the predicted travel time was 302.9870 seconds, and the predicted signal-to-noise ratio was 14.0 db. The predicted signal-to-noise ratios assume a perfectly reflecting target and an ideal, lossless system.

Table 1. Radar system characteristics.

Item	Characteristic
Transmitter	
Frequency	440 Mcy/sec
Pulse duration	2 msec
Peak power	265 kw
Transmitting-receiving antenna	
Form	84 ft steerable paraboloid
Gain	37.5 db
Polarization	
Transmitted	Circular
Received	Opposite circular
Equivalent noise input temperature of system	
Total	170°K
Antenna and feed	100°K
Maser and receiver	70°K

been made of the data for the two successful runs and has established that the fluctuation due to the background noise is in agreement with that expected theoretically. A theoretical analysis of the level of significance is thus justified. We have taken into account that the baseline fluctuations of Fig. 1 are not strictly normal, but actually high-order chi-square distributed (a conservative practice). The probability that background noise alone could have produced in these two runs, within the 600-millisecond range, cross-correlation peaks of amplitude equal to or greater than those observed, and having the relative alignment cited earlier, is less than 10^{-7}.

The strengths of the cross-correlation peaks on the successful runs imply that Venus is nearly a perfect reflector at 440 megacycles per second, if there are no scintillations. If there are amplitude fluctuations, however, the average reflectivity could have been considerably lower, since in the method of processing used here a signal contributes to the output in proportion to the square of its instantaneous strength. Of course this question cannot at present be resolved since it is impossible to observe individual returned pulses.

Among other checks that have been made on the planetary returns were analyses of their spectra which yield Doppler shifts in agreement with the astronomical predictions within the measurement uncertainties. Owing to the short pulses used, the accuracy of Doppler measurement is limited. There is no significant spectral broadening, so that presumably the returns are coherent over a 2-millisecond interval. On the other hand, no evidence of pulse-to-pulse coherence has been found. Examination of the raw data reveals no noise bursts, nor is there any indication of other than a statistically uniform buildup of the cross-correlation peaks with increasing integration time. All computer programs have been checked out on simulated signal-in-noise returns to check the correctness of the cross-correlation processing.

It is probable that the same techniques with minor improvements will be employed in the observations of Venus to be made at its next close approach, in September 1959. It appears possible, however, that a parametric amplifier may replace the maser.

Conclusion

It is evident that the success of the entire undertaking depended critically on the simultaneous application of significant advances in the state of several arts: (i) a maser operating in the 400-megacycle-per-second range; (ii) radar equipment combining high transmitter power and a large, precision antenna; (iii) digital recording and nonreal time digital processing of signals. It is felt that the advantages of such processing of received signals have been established for both passive and active radio and radar astronomy observations. The ability to "freeze" the data for later leisurely analysis appears to be important in an experiment in which a priori knowledge is lacking in several respects, and when there is only a relatively brief period in which observations can be made (*8*).

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Organization of Scientific Activities in Canada

The system avoids the dangers of changing political views and insures a high level of competence.

B. G. Ballard

The organization of science in Canada has been influenced throughout by an attempt to preserve the greatest possible flexibility. Certainly the system is less formal and less complex than that of the other countries discussed in this symposium. It is not suggested that the Canadian system would be suitable elsewhere or even that it solves all the problems peculiar to Canadian science. There are still weak points in the latter. The organization has evolved by adapting what was considered to be the best of the other systems and innovating where necessary to meet the conditions with which Canada is confronted.

Many factors affect such an organization. The population density and the area of the country are important. Even differences in governmental structure play a part. For example, the fact that the distribution of executive and administrative responsibility in the Canadian Government differs from that in the United States Government has probably influenced significantly the organization of science in the two countries. All countries actively engaged in science have charged their federal governments with the major responsibility for the development of science, and all have acknowledged the need for close integration between government science and the universities. Obviously, countries which delegate the responsibility for education to the federal government are likely to evolve systems different from that in a country like Canada where education is the responsibility of provincial governments and where there are in fact ten ministries of education.

In order to best understand the manner in which Canadian science has developed, it is well to review very briefly the historical events which contributed to its development.

The history of organized science in Canada really began in 1916. Prior to that time, scientific activity for the most part was sporadic and impoverished. The universities did not enjoy the generous endowments of some of their British and American counterparts, which would have enabled them to sponsor research on their own initiative, and industrial research was virtually nonexistent. Certain government departments had begun research in a limited way, but they devoted their efforts mainly to the solution of immediate problems in the fields in which they were held responsible. Basically they were handicapped because of lack of trained research workers. The need for science was not well understood. The value of research as an instrument for learning the secrets of nature as distinct from the application of known scientific laws and facts to the solution of immediate problems was not yet generally appreciated. Canada was still predominantly a pioneering country, and she was developing very effectively her mines and railways, her waterways and power systems. Her engineers had distinguished themselves with innovations which were most effective in solving problems peculiar to Canada, but, in the main, they relied for the supporting science on contributions from abroad.

It would be unfair to imply that there were no scientific achievements. Despite the difficulties, there were occasional noteworthy efforts. The Dominion Observatory, for example, which had been erected in 1904 primarily to provide a time service for the country, had facilities which made possible some fundamental research in astronomy. The staff of the observatory took advantage of the opportunity, and Canada has made significant contributions in this field, particularly in relation to the brighter stars. As a consequence, she has continued to play an important part in astronomical science and, for a time, had the largest telescope in the world. However, these cases must be regarded as exceptions rather than the rule.

It was not until World War I that serious consideration was given to making a nationally organized scientific effort, and even then the proposal was initiated in Great Britain. While England had made notable contributions in science prior to World War I, she had relied mainly on her universities and such institutions as the Royal Society and the Royal Institution of London for scientific advance. Government departments, of course, had their own laboratories, and the Armed Services were certainly well advanced scientifically as compared with the Canadian Armed Services. Nevertheless, there was little organized effort to promote scientific research, nor had the application of fundamental science to industry been promoted actively. Germany, on the other hand, had encouraged scientific effort by government support and had been extraordinarily successful in making use of science in her industries. By 1916, Great Britain was fully aware of the advantage that Germany enjoyed. As a consequence, she not only undertook to organize her own science program effectively but suggested that other members of the commonwealth should do likewise.

Accordingly, in the same year, the Canadian Government created a cabinet committee of six ministers to study the matter, and on their recommendation an Honorary Advisory Council for Scientific and Industrial Research was created. This was the parent body of the present National Research Council of Canada, and to the early research council must go most of the credit for the promotion and organization of scientific effort in the country. Briefly, its main purpose was to promote science in Canada, but that is an oversimplification. Certainly the original intention was not only that it should promote fundamental research but also that it should promote the application of this scientific effort to Canadian industry. The Advisory Council believed—and subsequent events confirmed the wisdom of this belief—that the immediate

The author is a vice president of the National Research Council of Canada, Ottawa. This article is adapted from an address delivered 27 Dec. 1958 at a symposium, "Moving Frontiers of Science: Comparative Patterns of Scientific Organization," held during the Washington meeting of the AAAS. This article and the following one, by Don K. Price, were presented during part 2 of the symposium. The papers presented during part 1 of the symposium appeared in last week's issue.

requirement was to encourage the best-qualified university students to pursue careers in research and to provide them with financial support. By 1940, the council had aided approximately 1000 of Canada's most brilliant students in science and had, as a consequence, a core of competent research men upon which to build when World War II began.

The council members did not confine themselves entirely to the problem of providing support for a potential body of scientists. They decided that they should survey existing research facilities. Their conclusion was that "these were pitifully inadequate," but that even more disturbing was the fact that there was an almost complete lack of public appreciation of the practical value of research. Most Canadian industries were subsidiary to foreign parent firms, and they relied on these foreign parent firms for their research, and even for their design. There had been no notable example of success in Canadian research to fire the imagination of the public. The Advisory Council believed not only that research workers should be supported in the universities but that government laboratories should be created which would stimulate the effort. Not only should these laboratories engage in fundamental research but they should also offer a service to industry so that it would be better prepared to meet the problems with which it was confronted in developing products.

It was not until 1928 that the Government agreed to proceed with the erection of a National Research Council laboratory, and in 1932 this was opened. Unfortunately, the early depression years were not propitious for an effective use of this new facility, but by 1938 the troubled situation in Europe revealed clearly the need for developing our scientific resources and, from that time on, the National Research Council laboratories grew rapidly. By the time war began, these laboratories had a competent core of scientists to meet the challenge.

At that time, the Canadian Armed Services were not well equipped with scientific facilities and, as a result, the National Research Council was named as the official defense laboratory for all three Armed Services, and for the duration of the war the laboratory worked under heavy pressure. Inevitably, the effort was devoted to applied research, and it was not until the end of the war that more fundamental research could be resumed on a satisfactory scale.

At the end of the war it became very apparent that the National Research Council could not discharge the duties for which it was created if it were required to meet the demands of the Armed Services for pure and applied research, and, accordingly, the Defence Research Board was created, with the responsibility of fulfilling these requirements for all three Armed Services.

Since the National Research Council and the Defence Research Board are by far the most important elements of organized science in Canada, I will discuss them first.

National Research Council

The name National Research Council has been used rather loosely and in the public mind applies either to the council which governs the laboratories or to the laboratories themselves, and the ambiguity persists throughout this article.

The council itself consists of 21 members, of whom only four are paid officials. The remaining 17 members are selected mainly from universities and, to a lesser extent, from industry. They are recruited from among the outstanding Canadian scientists across the country.

The term of appointment is three years but may be extended for an additional three years. As a matter of policy, members do not ordinarily serve for more than six successive years; this insures an adequate opportunity to provide, over a period of time, suitable representation from all interested groups and insures, also, a continuing replacement to bring fresh viewpoints into the organization. These men serve without remuneration, except to the extent that they are reimbursed for expenses in attending meetings.

The four paid officials of the council are the president and the three vice presidents, all of whom are statutory appointees—that is, the positions are laid down in the Act of Parliament under which the National Research Council operates. For reasons which are given below, the character of the Research Council is so completely nonpolitical that there has not been any attempt on the part of any government party to make political appointments to these offices. The president not only presides over the council but also is in charge of the laboratories. The three vice presidents are responsible to the president for administration, medical research, and science, respectively.

Perhaps the most unusual feature of the National Research Council is that it is not a government department, nor is it associated with a government department. Policy is determined by the council itself, most of whose members, as noted above, are completely independent and never under any political pressure. Moreover, unlike the situation in government departments, the selection of laboratory staff is approved by the council, and staff-members are not engaged through the offices of the Civil Service Commission. Purchasing also is administered by the council, and the arrangement provides somewhat more freedom in financing than is normally possible in a government department. Revenue earned by government departments normally is credited to "consolidated revenue" and does not accrue directly to the department earning it. The National Research Council, on the other hand, may retain its revenue and even carry it over beyond a fiscal year, in a so-called "special fund."

As indicated above, the council assumes responsibility not only for the operation of the laboratories but also for assistance to the science and engineering departments of Canadian universities in pursuing research work. This assistance takes the form of grants in aid of research, scholarships, and postdoctoral fellowships. It should be emphasized that the aid is confined entirely to research, as distinct from teaching, and thereby any possible conflict with provincial jurisdiction over education is avoided. Grants in aid of research to universities are made available only to individuals on the staff or, in some cases, to departments, and scholarships are available only to students who have already obtained their bachelor's degree.

One notable advantage of the special fund mentioned earlier is that the council may provide support to universities even though the Government's vote for the annual operation of the council may be delayed—a circumstance which is not unusual. When such a delay occurs, government departments are voted interim funds on a month-to-month basis, but the monthly amount is proportional to the estimate for the year, and therefore it is impossible to pay for large items of equipment which might be purchased in the early part of the fiscal year. It should be noted that the flexibility enjoyed by the Research Council applies only to its grants-in-aid program. The National Research Council laboratories are still subject to the same restrictions as government departments in this respect. The council's accounts are subject to normal government accounting practice and auditing, and funds may not be transferred

from operating votes to capital votes or vice versa, but otherwise there is relative freedom to use available funds in the most effective manner. The advantage becomes very apparent when council grants are compared with grants awarded by other bodies which are subject to a much more rigid control—sometimes so rigid that the effectiveness of the grants and development contracts is substantially reduced.

While the money obtained through revenue is not inconsiderable, the major portion of the money for the operation of the National Research Council is voted by the Government, and naturally the Government must exercise some control over the expenditure of the taxpayers' money. Accordingly, the council reports, not to a cabinet minister as such, but rather to a committee of the Cabinet, and it is the chairman of the committee who presents the council's budget to Parliament.

In one respect, Canada is very fortunate. Despite the fact that the per capita effort devoted to civilian scientific research by the Government compares favorably with that in the United States, the relatively smaller population makes it possible for all grants in aid of research and for scholarships to postgraduate students to be reviewed by a single body of men, thereby assuring a satisfactory relative assessment. These men are assisted in this work by the permanent staff of the laboratory, who undertake to provide the essential information in assessing the applications and proposals, but the final decision is made by the council itself. The aid from the National Research Council for research is substantially greater than that from any other Canadian body and is devoted to the promotion of both pure and applied research. Not only is money made available for research projects, including the equipment which may be essential for the specific projects, but special capital grants are made for the purchase of equipment which may be generally useful for research. Capital grants are usually made for equipment costing in excess of $5000.

However, every effort is made to avoid unnecessary red tape. Equipment purchased through grants, except in very special cases, becomes the property of the university, and the council makes no claim for patent rights on inventions which may result from the grants. A minimum of accounting is required. The restrictions imposed are designed mainly to insure that the money is spent in such a way as to benefit the maximum number of researchers to the greatest possible extent. For this reason, limits are imposed on the salaries which may be paid to graduate students, and, in particular, graduate students are not permitted to earn more than National Research Council scholarship holders. Money from grants may, through special permission, be made available for travel, and special travel grants are available to enable Canadian scientists to travel abroad.

Scientific Divisions

The laboratories of the National Research Council in Canada have eight scientific divisions, which devote their attention to applied biology, pure physics, applied physics, pure chemistry, applied chemistry, building research, mechanical engineering, and radio and electrical engineering, respectively. The council does not operate laboratories devoted to medical research, but the vice president in charge of medical research devotes his effort mainly to the support of medical research in universities and other institutions. He presides over a medical committee which recommends the award of scholarships to be made in the medical field. The final decision is, of course, still the prerogative of the National Research Council. In addition to the divisions mentioned above, which are located in the city of Ottawa, the council also has two regional laboratories, both devoted to biological problems. The one is located on the East Coast in the city of Halifax, Nova Scotia; the other, in the prairie region in the city of Saskatoon, Saskatchewan. There are also other stations located in other parts of the country for specific purposes, including some in the Canadian North.

Almost from their inception, the laboratories of the National Research Council were keenly interested in aerodynamics and aeronautics. The mechanical engineering section of the Division of Physics and Engineering constructed a wind tunnel in 1930, and from that time on, interest in the subject increased rapidly. By 1940, the mechanical engineering section was separated from the Division of Physics and became the Division of Mechanical Engineering. It began the construction of a new and larger wind tunnel, and as time went on it added further facilities for research in aerodynamics and in the development of aeronautics. The value of this service is inestimable, and as a result, some distinctive Canadian types of aircraft emerged. The Division of Mechanical Engineering provided the major aeronautical facility in the country; later it was formed into the National Aeronautical Establishment, operated by the National Research Council. The work has been carried on in close collaboration with the Armed Services, the Defence Research Board, the Department of Transport, and industry. Government interests are represented on the National Aeronautical Research Committee, which is the policy-making body for aeronautical research. Industry is represented through advisory committees.

While the Defence Research Board, as mentioned above, was created to assume responsibility for scientific work in connection with the Armed Services, the National Research Council still plays an important part and assists in several phases of defense. The work of the National Aeronautical Establishment is only one example of this defense activity on the part of the National Research Council.

While the council has a strong group engaged on fundamental research, slightly more than 50 percent of its effort is devoted to applied research. This work may be undertaken on the initiative of the laboratory, subject always to the general control of the council, or at the request of industrial or other organizations, in which case a charge is made. In addition, the council operates a Technical Information Service, which will provide industrial or other organizations with available technical information without charge. The Technical Information Service is generally operated in connection with provincial research organizations, to which reference is made below.

The council is charged with the responsibility of providing and maintaining the legal primary standards of the country.

The council's library is the most complete in the country in the technical field and is really a national scientific library for Canada. Its services are available to all persons having a need for technical information, and in addition to lending books and periodicals, it provides, where necessary, a photostatic and microfilm service.

An important factor in the council's operations is the system of postdoctoral fellowships which has been created. This makes it possible for a scientist at doctoral level to pursue work in a field of his choice and in association with a scientist of established competence in that field. The scholarships are tenable in universities and in certain government departments. They are awarded by the

National Research Council and, in the case of postdoctoral fellows in universities, are paid for by the council. The council maintains close control over these fellowships, to make certain both that a high standard is maintained and that fellows are placed in organizations having facilities that will enable them to develop intellectually. These fellowships are available, of course, to graduates outside Canada as well as inside and, in the case of Canadian students, may be held in foreign laboratories.

Shortly after the National Research Council was formed, it instituted a system of associate committees for the purpose of planning programs of research in various fields of activity, bringing into these committees representatives of interested government departments, universities, and industry, as well as individuals in a special position to make a personal contribution to the problem being studied. There are now 28 associate committees.

Nuclear Research

No résumé of science in Canada would be complete without some reference to nuclear science. Early in World War II Canada embarked on a study of nuclear physics, aided by many scientists from abroad, some of whom had escaped from Europe just before the German invasion. This work developed rapidly, and it was encouraged by the discovery of large deposits of uranium in the country. Security restrictions demanded that the work on nuclear physics should be well isolated, and it was absorbed by a separate branch of the council. The branch quickly assumed a position of special importance, and, of course, its annual budget grew accordingly. The production of radioactive isotopes became a significant item in its operations. With the advent of this commercial aspect of research, the branch reached a size which warranted separation from the National Research Council, and a Crown company was created which continued to distribute radioactive isotopes and also continued research in the nuclear field. This organization is the major center of nuclear research in Canada, although there is increasing development of nuclear research in Canadian universities.

The Atomic Energy Control Board, which controls the distribution of radioactive materials in the country, also awards grants in aid of research through the National Research Council, generally in the nuclear field. More recently, Atomic Energy of Canada, the Crown company mentioned above, has collaborated with industry and utilities in the development of an atomic power plant.

Defence Research Board

As indicated above, the Defence Research Board was created shortly after the close of World War II, and the board itself is selected in very much the same manner as that of the National Research Council; however, it comprises a greater percentage of paid officials, largely because a representative of each of the three Armed Services sits on the board. Of the 16 board members, seven are ex officio and are paid government officials. At the present time three other members are appointed from government organizations and are paid officials. Often there is an interlocking of membership between the Defence Research Board and the National Research Council, and at all times there is the closest collaboration between the two bodies. There is one major difference, however, and that is that the Defence Research Board operates within the framework of the Department of National Defence.

As in the case of the National Research Council, the Defence Research Board gives grants in aid of research, and the board's assistance to universities has become an important factor in the development of science in Canada. It operates, of course, an extensive system of laboratories. Most of the effort is devoted to applied research of direct interest to the Armed Services, and even the more fundamental research supported by the board is selected with a view to its potential defense application. The Defence Research Board enjoys a much greater freedom in the selection of staff than do government departments in general, being comparable with the National Research Council in this respect. However, purchasing is more restricted than it is in the Research Council, and the essential security regulations do impose other restrictions. For example, it is not practicable to introduce the postdoctoral fellowship scheme in the Defence Research Board because of security problems. The laboratory staff is civilian, and the chairman of the board enjoys a status equivalent to that of a chief of staff and attends meetings of the Joint Chiefs of Staff.

Despite the obvious emphasis which must be placed on applied research, the Defence Research Board has found it possible to devote a significant effort to more fundamental research, and encouraging results have emerged. Its major establishments are the Pacific Naval Laboratory at Esquimalt, British Columbia; an experimental station at Suffield, Alberta; a northern laboratory at Fort Churchill, Manitoba; a medical laboratory in Toronto; a series of chemical, electronics, and radiophysics laboratories in Ottawa; an armament research and development establishment outside of Quebec City; and a naval research establishment at Halifax, Nova Scotia. There are, of course, in addition several stations in various parts of the country devoted to specialized investigations.

Because of the smaller scale of military operations in Canada as compared with those in the United States, it is possible to have a single organization to assume responsibility for the scientific efforts of all three Armed Services. Some of the work is undertaken under contract with industry and universities, and some is undertaken by the National Research Council.

Obviously, it would be inappropriate to outline the applied fields in which the Defence Research Board is active, but it is of interest to note that the more fundamental fields embrace oceanography, physics, chemistry, the ionosphere, electromagnetic propagation, and so on.

Other Government Research

Several other government departments have research establishments, but they operate on a much smaller scale than either the National Research Council or the Defence Research Board, and they devote their efforts largely to practical problems with which the departments are confronted. Nevertheless, as in the case of the Dominion Observatory, most of these departments do undertake some fundamental work. Because of the very intimate responsibility of each government department for scientific developments in its particular field, there has never been a suggestion that the scientific work of the various departments should be consolidated in a single laboratory. While these activities may not be regarded as "organized" science, it is important to recognize their existence and the fields of activity covered.

The Department of Agriculture operates extensive laboratories in various parts of the country, and there is some very effective fundamental research in progress under the auspices of the Science Service Division. This division con-

cerns itself with bacteriology, botany and plant pathology, chemistry, entomology, and forest biology.

The Department of Northern Affairs and National Resources operates a Forest Research Division and a Forest Products Laboratory. The latter laboratory concerns itself mainly with the properties of wood and timber and their application.

The Department of Mines and Technical Surveys operates an extensive Mines Branch Laboratory, which deals with fuels (mainly fossil fuels), industrial minerals, and metallurgy.

The Fisheries Research Board, originally organized in 1912 as the Biological Board of Canada, was reorganized in 1938 under its present name, and its laboratories are operated by the Fisheries Department. It has stations on both the Atlantic and Pacific coasts as well as an inland station in the Province of Quebec. It studies fishing techniques as well as processing, preservation, and conservation.

The Department of National Health and Welfare maintains laboratories, mainly for the protection of the public rather than as instruments of research.

Several other government departments, including the Department of Public Works, the Post Office Department, the Department of Justice, and the Department of Transport, operate small laboratories for the study of specific departmental problems, but these activities could hardly be regarded as organized science in the sense in which the term is considered in this article.

Where coordination of effort is required, there is an advisory panel composed of the deputy ministers of those government departments most actively engaged in science. The chairman is the president of the National Research Council.

Provincial Research

Because of local problems with which they are confronted, some of the provinces of Canada have created research organizations; these are devoted mainly to applied research, but some of them undertake a limited amount of fundamental research. Some of the latter receive financial assistance from the National Research Council. In general, the provincial research organizations concern themselves with the development of provincial industries, and they work very closely with industry. Somtimes they are self-supporting, except for very minor grants. In all cases, research is under the direction of a board or council, and some of the organizations operate locally in a manner very similar to that in which the National Research Council operates on a national scale. The provinces of British Columbia, Alberta, Saskatchewan, Ontario, and Nova Scotia have such facilities.

University Research

As indicated above, university research is supported largely by the National Research Council and the Defence Research Board, but other organizations make important contributions. The Industrial Foundation on Education was organized in 1956 by some of the major Canadian industries. The main purpose of the foundation is to foster scientific education both in secondary schools and in universities, although its effort is not confined entirely to science. It has undertaken to provide financial support without limiting in any way the freedom of the universities and to assist the teaching staff as well as support research. Industry frequently gives local assistance.

Within the last two decades the purer sciences have developed markedly in Canadian universities, and most science departments have built very effective research teams and are making significant contributions to the world's science.

Through the generosity of various agencies, some of the universities have been able to install expensive equipment to provide research facilities for staff and students. An atomic reactor is being installed at one university, and particle accelerators are available at others. The engineering departments have not advanced so rapidly, but very recently there has been encouraging activity. Whereas a few years ago most of the engineering staff engaged in consulting practice during the summer, many are now remaining in the universities to pursue research.

Industrial Research

Industry still relies very extensively on foreign parent firms for research, development, and design. The chemical industries are an exception, and there is a growing tendency for other industry to become more independent. It seems likely that this trend will accelerate. A number of firms have set up research laboratories, although some have done so not so much for the benefit of their own products as for the purpose of undertaking development contracts for the Government or other bodies. There has been an increasing record of achievement in the industrial laboratories, and a number of new products have been developed which have enjoyed outstanding commercial success. Some industrial laboratories are handicapped by the fact that they must sell their services to the other divisions of their respective companies, which, because of their ties with parent firms, have little interest in laboratories except for control purposes or to insure that either the purchased materials and components or the finished products comply with specifications, and opportunities for speculative research are inadequate.

Research associations have not been as popular in Canada as in Great Britain, probably for the reason mentioned above. Nevertheless, at least two industries have formed associations, and one in particular has achieved an encouraging degree of success.

There are no privately endowed, self-supporting research institutes of the type which has developed so successfully in the United States.

Conclusion

While the per capita effort devoted to government civilian science in Canada compares favorably with that in most other highly industrialized countries, the relatively small population makes possible a much more compact scientific organization, and there is a corresponding reduction in the problems associated with the organization of science. It is possible to have one organization which in large measure performs the functions of the National Science Foundation and the National Bureau of Standards in the United States. To a lesser extent, portions of the National Research Council, acting in collaboration with the Defence Research Board and the Department of Transport, serve a purpose similar to that of the National Advisory Committee on Aeronautics in the United States and its successor, the National Aeronautics and Space Administration. Nevertheless, aside from the advantages that Canada enjoys because of the reduced scale of operation, the organization has avoided many of the difficulties which arise because of restrictions necessarily imposed upon government departments. It is believed that the Canadian system avoids

the dangers of changing political view and at the same time maintains an effective control to insure a high level of competence.

Canada possesses a wealth of natural resources, and their development will make heavy demands on science. Progress has been encouraging, particularly in the fundamental sciences, but there are still areas in which greater effort is required. Undoubtedly, increasing population and increasing university effort will introduce greater complications in organizing effectively for the future scientific activities of Canada. It seems likely that the trend will be a growth of the National Research Council to a point at which some portion becomes disproportionate in size to the remainder, and that this portion will then be separated and embodied in a new organization, in much the same manner that Atomic Energy of Canada achieved separate status.

Organization of Science Here and Abroad

Varying national patterns for support of science result from basic constitutional differences.

Don K. Price

In considering the merits of various forms of government, and particularly of the various patterns of government organization for the support of science, it is a great temptation to think in conventional mechanical terms. The organization chart has bemused us into believing that we have a simple choice to make between various clear-cut alternatives; as one author recently put the matter, political science is a much simpler subject than any of the natural sciences, because there are basically only a few different forms of government and the problem is simply to select one of them.

But this general symposium, I am glad to see, has not fallen into this way of thinking, which is as obsolete in the 20th century world as Newtonian physics. Hiscocks, in describing a system in which the status of science is intertwined with the rich historical traditions of the Privy Council; Ballard, who looks on government organization in Canada in its complex interconnection with the structure of great international business corporations; and Major, whose account of similar problems in Norway leads us into the background of three Scandinavian dynasties, the future complexities of European integration, and the contemporary arrangements for diverting football pools into the support of research—all of them have illustrated the fascinating complexity of our problem.

But I do not think I can follow their example and give you, with respect to the United States, a summary outline of our scientific organization. My assignment is rather to draw comparisons. This, I think, can be done best not by looking closely at organization charts but by trying to trace some of the main threads of similarity and difference that mark our several systems. And if I note some of the unique points in the American system, no one should take me to mean that I consider them points which other countries should imitate. Hiscocks, for example, was quite right in suggesting that in many ways an ideal pattern would lie somewhere between the British and the American extremes.

I am tempted to define those extremes by comparing the official role of science in British society with the way in which American scientists actually operate. Hiscocks quoted Hooke as defining the role of the Royal Society thus, in the 17th century: "To improve the knowledge of all natural things . . . by Experiment (not meddling with Divinity, Metaphysics, Moralls, Politicks, Grammar, Rhetoric, or Logick)." Science, like administration, has always in the United Kingdom dutifully acknowledged its subordination to, or at least its separation from, politics. If we are to contrast our classic traditions, I would like to recall the chief of the Patent Office in the days of John Quincy Adams who was discharged not for lack of scientific ability but because he grossly neglected his duties in order to spend his time in stirring up republican revolutions in Latin America.

But this is an unfair contrast. Much more to the point is Hiscocks' observation that the British are traditionally strong on the side of basic science; the Americans, on applied science and engineering. We may note a parallel tendency with respect to the type of interest that natural scientists typically take in governmental affairs. For in recent decades it has been the British and European scientists who have shown their interest in governmental affairs by theoretical writings on the relation of science to politics, while in politics, as in science and technology, the interest of leading American scientists has been channeled into participation in specific program fields. For some reason it is we, rather than the British, who are working things out in this business by a pragmatic rather than an abstract philosophy.

If we are to search for an explanation, I am tempted to follow up on Ballard's cue. He noted that "the fact that the distribution of executive and administrative responsibility in the Canadian Government departs from that in the American Government has probably influenced significantly the organization of science in the two countries." For what he says of the Canadian government applies, I believe, to the Norwegian as well, and even more to the British.

Mr. Price is dean of the Graduate School of Public Administration of Harvard University. This article is adapted from an address delivered 27 Dec. 1958 at a symposium, "Moving Frontiers of Science: Comparative Patterns of Scientific Organization," held during the Washington meeting of the AAAS. This article and the preceding one, by B. G. Ballard, were presented during part 2 of the symposium. The papers presented during part 1 of the symposium appeared in last week's issue.

Two Currents of Thought

To begin the story, let me look back a bit into history. Among American scientists, in relation to politics, there have been two main currents of thought. The first was the dominant one in the days of the founding fathers. Men like Thomas Jefferson, Benjamin Franklin, and John Quincy Adams were by modern standards merely amateurs of science. But among them were a few who were accepted as leaders by European scientists of the day, and in no other country did practical statesmen put such faith in the potential contribution of science to public affairs. In France the scientists became Encyclopedists, but the effect of the Great Enlightenment in America was to bring scientists directly into statesmanship, and to make even our lawyers think in terms derived from science rather than from tradition—rather like Chancellor Kent who hoped that our political institutions would draw their strength from "free investigation and faithful experiment."

But like many a revolutionary impulse, this one came from the learned rather than the popular elements and faded rapidly as the popular elements gained the ascendancy. With the Jacksonian democracy the frontier attitudes triumphed. It took many years for John Quincy Adams to persuade the Congress to accept the endowment offered by James Smithson, and none of the early presidents could put over their pet idea of a national university. By mid-century the scientists were disillusioned with frontier democracy and were advocating the creation of a National Academy of Sciences, with a wistful eye on the honorifics and prestige that were attached to the academies of Paris, Berlin, and Saint Petersburg.

But soon science came back as an active force in our politics in forms that Jefferson and Adams could not have foreseen—forms that fit the peculiar structure of our society and our federal system of government, and that have rarely been appreciated, at home or abroad. Perhaps we can identify the patterns of this development best by asking general questions. How well off is the scientist in American government? What influence does the science adviser have on general policy? How is science supported?

If we can distinguish some pattern in the answers to these questions, we may also speculate with respect to the future effect that science may be having on our political, economic, and social institutions.

In Civilian Government

First, then, how well off is the scientist in the American government? The European or Asian intellectual, particularly during the McCarthy period, has been inclined to think that the American scientist, like the American literary figure, has no status or influence in American politics or administration. This notion comes, of course, as a great shock to anyone who grew up in the Washington bureaucracy. For he takes it for granted that in the American civil service it is the scientists who have the greatest prestige and the best salaries. It is the scientific civil servants for whom the Congress earmarks the great majority of positions for whom exceptionally high salaries are permitted, and whom the congressional committees call for independent advice on the most fast-moving fields of public policy. And it is the scientists who move up into the top administrative positions in most of the federal bureaus whose programs have anything to do with science. All of these things happen as a matter of course in Washington; but all of them would be quite impossible in the governments of Canada, the United Kingdom, or most countries in Europe.

The reasons may be seen plainly in the history of the United Kingdom, which set the pattern for Canada and, to some extent, for Norway. The 19th-century reform of the British civil service was not a reform to abolish a spoils system. There was no spoils system to begin with. The merit system, on the contrary, was needed to replace a system of family or semifeudal patronage in which a civil servant acquired almost the same vested interest in his job that he would have had if he had acquired a church living—which was, indeed, in many cases his alternative. This was a system of great stability, high order, and authority; the effect of the new competitive merit system was to make it efficient. And all this was done before the scientists began to enter in great numbers. When they did come in, they came in beneath an administrative layer of high prestige and fixed status, in which the career administrators and the career politicians had studied the same classical curriculum at the same senior universities and were members of the same clubs.

In the United States the story was radically different. Here in the mid-19th century, the greater instability in our public service was at the top. Rotation in office plagued particularly the top administrative jobs. Civil service reform was begun at the bottom and worked upwards. And it moved upwards furthest and fastest when it was the scientists rather than the reformers who took the lead. Not many years ago most of the career bureau chiefs had come up through the scientific and technical fields. This came about in part because there was no fixed career hierarchy to block the way. In part, it was because Congressmen could be persuaded to give up patronage most readily in positions that had highly specialized and scientific qualifications; you could prove that an ordinary politician did not know how to design a lighthouse or build a bridge or work out tables of navigation, but politicians were more confident that they could fill positions requiring general administrative competence. And finally, it was in the scientific and allied professional fields that there was enough *esprit de corps* to lobby for freedom from politics.

The greater status and prestige of the scientists in American administration went so far as to lead to imitation by the nonscientific fields. Indeed, many of the difficulties in our personnel system which scientists protest most bitterly have come about because personnel specialists know they can defend themselves against political criticism most effectively by creating a system depending on detailed objective tests and quantitative methods and involving its own technical jargon. The excesses of politics have been restrained by pushing forward the scientific frontiers, but in the process not enough room has been left for general administrative judgment.

The Military Side

I have been talking, of course, about the civilian side of American government. The contrast with the military side is as instructive as the contrast with the British system. Civilian scientists in the United States military departments complain that their chances of promotion are blocked by the military habit of reserving top administrative positions for career officers—a complaint which British scientists have traditionally made against the civilian administrative class.

In the United States military service each department's career service is headed by an officer who is unquestionably the peak of the hierarchy. By contrast, in a British military service no officer has an equivalent position of undisputed command; the chief of staff sits as a member of the Army Council (and as the First Sea Lord on the Admiralty Board), which somewhat dilutes his authority and his control over such key matters as top promotions. The contrast on the civilian side between the two countries is in exactly the opposite direction. In the United Kingdom each civilian department is headed, under the minister, by a single career permanent secretary, whereas in the American civilian department there is no career position which even remotely resembles the peak of a hierarchy for policy and administrative purposes.

Yet, paradoxically, this status of the military career officer in the American government confirms rather than disproves the general difference I was trying to describe, because the American military officer won his position in the eyes of the Congress as simply a superior kind of scientist or technician. The ideal of the citizen soldier—the politician leading the troops—died hard, after Washington and Jackson and Theodore Roosevelt. But career military officers won their status by persuading Congressmen that a special kind of knowledge and skill was necessary for positions of command. The process of persuasion, however, required more than a century of advance in military technology, and the rational arguments were buttressed by the political influence of the dams and levees of the Corps of Engineers.

It is this difference in the fundamental status of the career civilian administrator and the career military officer that explains, I think, a major difference in scientific organization among our several countries. In Great Britain it is possible to assign Army and Air Force research to a Supply Ministry, and to make even the Royal Naval Scientific Service a predominantly civilian agency, because the basic decisions on government organization and administration are made by the Prime Minister and Cabinet on the advice of the civilian career administrators. (Much the same might be said with respect to the unification in a single institution of all defense research in Canada, to the membership of a civilian scientist on the Canadian Joint Chiefs of Staff, and to the creation in Norway of a single defense institute).

Hiscocks mentioned that in 1957 the Prime Minister decided to transfer to himself from the Lord President responsibility for the atomic energy program. Let us not overlook the procedural significance of that statement. An equivalent decision in the United States could not be made by the President; it would involve the submission of a bill or a reorganization plan which would be vigorously debated in the Congress, and the possibility of such debate or of the amendment of such a bill would condition the decision about whether the measure should be prepared and submitted at all. Look, for example, at the way in which the National Aeronautics and Space Agency has just been created, or in which the organization of the Department of Defense has just been amended, both after extensive committee hearings, with testimony from all levels of scientific and military authority and endless compromise and amendment by the legislative committees. The equivalent step was taken by the United Kingdom in 1958 with the release of a brief paper on the new organization of the Ministry of Defence; this, the paper said in effect, is a scheme which we decided to try out some time ago, and now that it seems to be working well we think it proper to inform the Parliament and public about it.

If we measure the scientist's status in American government by the possibility of his moving to high administrative positions, it is better than that of his Canadian, or British, or European colleague. By contrast with the classic British system, just as there is no clear distinction in the American public personnel system between political and administrative positions, so there is no clear distinction between scientific and administrative positions. Indeed, much the same contrast can be drawn between American and British industry, since scientists and engineers seem to move more readily into top management and membership on boards of directors in America than abroad. There is no question that here is a significant difference, but whether on balance the difference is in our favor I will not stop to debate. As Hiscocks noted, it is not alway good for science or for administration to make a good scientist into a poor administrator. Some, however, may be tempted (with me) by the nature of our current problems to think that only a certain admixture of scientifically informed individuals can qualify an administrative corps as adequate in the world of tomorrow.

Effect on Policy

Then what influence does the scientist adviser have on policy?

In a broad and general sense, of course, the developments in science and technology have had a determining effect on government policy everywhere. But here we are concerned with the much narrower question: "Are there ways in which the channels of scientific advice to those who determine public policy are different in the United States from elsewhere?"

First of all, I think we can tell even by reading the daily headlines that scientists take their advice directly to the Congress and the public as well as to the responsible executives. When I mention such headlines I am thinking less of Killian than of Von Braun, whose views not only on the technological aspects of space travel but also on the distribution of functions and personnel among various government agencies have received more column inches in the daily press than have the views of responsible agency heads. Such manifestations are a constant source of wonderment to our visitors from abroad.

The differences are partly, but not mainly, a matter of different journalistic habits. Hiscocks has described the parliamentary system in the conventional. and perfectly acurate, terms of a system in which the executive and the legislative body cannot be in conflict with each other, because the executive is in effect a committee of the legislature. This is only a part of the story. With respect to the problems we are discussing, two other aspects of the British parliamentary system are equally important. The first is that under this system the party in power, through its ministers, takes full and exclusive responsibility for policy: that is to say, subordinate officers, administrative or scientific, are not permitted to express their views on policy or to appear at all before the legislature or any committee thereof, and indeed the legislature is not permitted to set up a committee which can have a voice in determining policies within a particular field. The second is that the parties compete within the limits of clearly defined ground rules; they compete on broad policies and leave the basic responsibility for organization and administration to the executive. The Cabinet and the top civil servants together are the heirs to the traditional authority of the Crown; it is they, and not the House, who determine how Her Majesty's Government

shall be organized. It is for this reason that the organization or reorganzation of major functions, as I mentioned above, is not a matter of political debate.

The system in the United States could not be more different. The direct access of scientists to congressional committees on policy issues is not a new phenomenon. It began when the Franklin Institute, with a federal grant for research to find out why steamboat boilers were blowing up, went on with a magnificent disregard for its terms of reference to propose draft legislation for a federal system of steamboat inspection. This was the first federal function of regulating private business; it came at about the same time as the first Factory Act in Great Britain; after these two acts, *laissez faire* was doomed. But while this first step of the House of Commons was proposed by a cabinet minister, that of the United States Congress was recommended to it by an independent research agency. And the Steamboat Inspection Act set the pattern for the 19th century. While political leaders debated great abstractions like states' rights and free trade, the scientists and associations of scientists were the cutting edge of new policy in the functions that were involved in the development of a new continent. In the geological surveys, the mapping and charting of the coasts and inland waters, the development of new types of agriculture, and the conservation of forests—in all of these fields you find variations on the same pattern. Groups of scientists, usually backed by some institution like the American Philosophical Society or the American Association for the Advancement of Science or the National Academy of Sciences, persuade the Government to support new surveys or research activities. Then research contributes to the development of regulatory or service functions. And, given the lack of a strong corps of career administrators, the scientists move on into positions of administration and policy leadership —at the cost of exposure to political pressure and legislative questioning.

Effect on Organization

The same contrast appears in issues of organization that appears in issues of policy. In the United Kingdom the fundamental view has not changed since the House of Commons won a status of apparent omnipotence; it is agreed that the contest over policies, on which the tenure of the executive depends, would give the nation no basis of judgment between the parties if policy issues were confused by being mixed up with issues of organization and administration. Responsibility for the latter must be firmly fixed in the government of the day, which in theory means the Cabinet but in practice means the career administrators.

The American view, by contrast, has not changed fundamentally since the Government was founded through a revolt against constituted order and authority. In spite of the limited powers that have been delegated to the President for government organization, the country and the Congress still basically look on the problems of organizing and administering the Government as a part of the policy issues on the political agenda.

Then how does all this bear on the question of how science should be represented in the high policy councils of the Government?

The greatest advance in this respect, of course, has been the creation of the office of the Special Assistant to the President for Science and Technology—the position held with great distinction by Killian. His office is sometimes discussed in the same breath with proposals for a new Department of Science, but it seems to me that the two differ, not merely in degree but fundamentally in approach.

If the purpose is to enhance the status of science or its usefulness to society (within reasonable limits the two purposes are, I think, compatible), the main strategic question is whether to try to strengthen science as part of nearly all the departments and agencies of government or to centralize it as much as possible in a single department.

A conventional step toward agency prestige in Washington is to get status as an executive department, which by tradition (not law) carries "cabinet rank," or the right to be present in the President's cabinet meetings. But the price paid for this prestige is that a department must get its powers and its funds by legislation, and its head must be confirmed by vote of the Senate; thus the prestige that comes from direct power must be fought for in the political arena. This battle always involves rivalries among departments as well as between parties. Few things in politics seem more obvious than the probability that almost every executive department would join, together with its political friends in Congress, in attacking any proposal to pull its scientific research agencies out and transfer them to a central Department of Science. The secretary of such a department, in order to exist, would be committed to constant political warfare. In such a situation, he would be quite unable to serve as a close and confidential adviser to the President.

Even the National Science Foundation, which was set up with limited functions to avoid such conflict, has had to tread warily. The legislative battles over its creation resulted in a compromise that gave it a large board of directors; the nature of the foundation's functions, its relationships with other agencies, and the complexities of its director's relations with his board, all may have contributed to making it impossible for the foundation's director to serve also as the principal science adviser to the President.

For the President cannot accept anyone in that position whose main allegiance must be to a private group (as is the case with the president of the National Academy), or whose executive responsibilities require him to maintain his own political following vis-à-vis the Congress. Only a man without other operating responsibilities or competing loyalties, and hence one who is not looked on as a rival by the executive departments, can be accepted in such a role.

These considerations are important in the United States simply because the internal problems of government organization and administration are just as exposed to legislative and political questioning as are the issues of basic policy themselves. Here again we see our own situation illuminated by contrast with that of countries in the parliamentary tradition. In the United Kingdom, for example, all the arrangements such as those we have been discussing are generally sheltered from political attack or legislative amendment. It is significant that they are given such status by being attached to a member of the Cabinet who is a survival of the royal prerogative—the Lord President of the Privy Council. Under that kind of shield, a scientific adviser can be given high honorific status without difficulty or danger. But in the United States, to formalize an arrangement by statute is to make it rigid. Such status cannot be given without the possibility of undesirable amendments, and to win and maintain such status, especially at high policy levels, is to jump into politics without protection. Killian's position avoids such difficulties. His close and confidential relationship with the President depends on a lack of independent political status rather than on having such status given him by statute.

Financial Support

Then we come to our third question: How does science get financial support? We have learned from Hiscocks, Major, and Ballard of the various arrangements made for this purpose in other countries. All these arrangements have as their primary objective the guaranteeing of a measure of independence and detachment to scientific research, while giving it support through political processes. Thus we have heard how Canada, in order to support advanced research, tacitly assumes that postgraduate education is not education at all, so as to avoid having it come under the ban against federal support of education in a country whose provinces are even more jealous of federal authority than are our states. We have seen how Norway channels gambling revenue into the support of science through the laws regarding its football pools—a method neglected in this country since the Puritan Commonwealth of Massachusetts conducted a state lottery to build Holworthy Hall for Harvard in 1812! But the two methods that are worth special comparative comment are those of Great Britain—the industrial associations and the University Grants Committee.

Block Grants

The common element in these two devices is the idea of the unrestricted block grant, in contrast to the provision of funds through grants or contracts on a project-by-project basis. With respect to the industrial associations, where the scheme is for the Treasury to supply part of the costs for the support of a laboratory serving a trade association, the American antitrust lawyer would undoubtedly shudder with horror at the very idea. But the fundamental issue is broader and one on which the industrial associations have a common position with the universities—and for that matter with counties and municipalities, which also draw a heavy proportion of their revenue in the United Kingdom from the national Treasury. All of them rely largely on block grants, and all of them dislike the grants which are tied to specific purposes, as were most municipal grants some years ago.

The idea of block grants has a great deal of appeal, on the surface, to American educators, who with reason dislike the idea of federal authority being extended over their institutions in a piecemeal project-by-project fashion. But the U.S. Civil Service Commission and the U.S. General Accounting Office are monumental reminders that imitations of British public institutions sometimes work quite differently in the United States. What would happen if we tried to create a university grants committee?

It is worth noting that in the United Kingdom the University Grants Committee system covers up all sorts of implicit issues which never reach the attention of the House of Commons. That is its purpose. To take only a single example, grants from the UGC to Oxford and Cambridge go to support a system of education (the tutorial system in the residential college) that is very much more expensive per head than the system followed in the provincial universities. This can be done only because the members of the UGC, no matter what their present connections, find it possible to concede that Oxford and Cambridge provide a superior kind of education, and that it is in the national interest to pay extra for it. This is admittedly a matter for political judgment, but I do not believe that a similar committee, representing the land-grant institutions, the state universities, the church-supported colleges, and all the rest, would ever concede any such point on the American scene, and if they did I can well imagine what would happen in an appropriations subcommittee the following year.

Project Grants

It was to avoid the danger of converting federal aid into political patronage that Congress, as it began to authorize grants to state institutions for various programs (such as agricultural experiment stations) generally provided that the grants be calculated on the basis of some statistical formula. This approach will work if the purpose is to spread a system uniformly over the country. But if the purpose is to build up various centers of excellence, or to get specific jobs done, in private institutions, a different approach becomes necessary; hence the development of the system of grants and contracts for individual research projects. Only this system can anticipate and satisfy political criticism, which is reflected most vividly—although it by no means always originates—in congressional committees. A system of grants can be defended most easily if it seems to be based on objective judgment and to be closely related to the purpose of a specialized program. It helps, of course, if the field in question possesses a strong and well-organized professional society, which is eager to defend the integrity of professional judgment against interference on general political grounds. Thus, the Office of Naval Research or the National Science Foundation or the National Institutes of Health can administer grants to individual institutions on a discretionary basis without too much political trouble. For the very specificity of their purpose is the best defense against their being required either to pass out funds on a per capita basis or to yield to demands for patronage.

It is surprising not that basic research has lagged in the United States but that it has been possible to find federal funds for it at all. The distinction between basic and applied research, however, is as fuzzy as the distinction between applied research and procurement. And the very fuzziness of the distinction has been a great advantage. Until the end of World War II nobody supposed that it was a basic purpose of the Federal Government to support basic research at all, and even since the creation of the National Science Foundation it is doubtful whether the motive of adding to basic knowledge provides an adequate political support for the sums of money that now go to fundamental science.

Political executives and legislators are not in the best position to decide, on general grounds, what fraction of any given budget should go to basic, as contrasted with applied, research. They are reasonable enough, however, to go on the tacit assumption that such decisions can best be made by the people working in the field, especially if the structure of that field is such that scientists can attain positions of authority within it. John Quincy Adams and the presidents who went before him lost in their attempts to create a national university for the support of scientific research; they lost only because they insisted on thinking in terms of a model which did not fit the American federal pattern. They lost, but only to see the same purpose served many times over, first by the creation of land-grant colleges and next by the allocation of federal funds for the support of research to a wide variety of institutions, public and private alike.

The approach that has served well in the past may not be the best for all time to come. Whenever the general public and the Congress become persuaded that the support of basic research is important enough as a national purpose to warrant the setting aside of considerations of partisan, sectional, or local ad-

vantage, perhaps we can then move to another system involving federal grants for general support of the best scientific institutions in the country. But in the meantime, the project grant or contract has provided considerable support for research without interference from partisan politics. Thus, it has paradoxically served the same purpose in the United States that the University Grants Committee has served in Great Britain, even though in form the two approaches are entirely different.

Science and Society

If this is so, it suggests that science may be having a profound effect on our governmental and economic institutions —not merely through the effects of technological change or government programs but also through the form of institutional response that is made to such change, or even through the institutional arrangements for bringing about such change. Many scientists who are properly concerned with the unique contribution of the individual human intelligence to research are made uneasy by any talk of science as an organized system. But there is no way out of it. As Whitehead pointed out, the greatest invention of the 19th century was the invention of the method of invention, and very few scientists indeed are purist enough to take no interest in the contribution of science to technological advance. But even if we should be interested in science only for its advancement of abstract knowledge by basic individual research, we still, under modern conditions, have to think of it as an organized form of activity. For to give the scientist protection against other demands on his time and the laboratory and other tools needed for his job requires a highly organized system within our society.

So now I come back to the interesting point of speculation on which I touched at the beginning. Why did so few American scientists follow Bernal and Joliot-Curie and their many colleagues in Europe and Asia in accepting the Marxist view of the relation of science to human society? Perhaps it was because Marx had been looking at the 19th-century problems of an industrial and urban society, while the basic patterns of a large part of American science in its relation to government were set during the 19th century, in an agricultural and rural nation. In a sense, the frontier was a force for freedom. But this was only because we worked through free institutions to develop it; Siberia too was a frontier, but its name became a synonym for something quite different. What we developed was a system too fluid and dynamic to bear any resemblance to Marx's rigid class assumptions. And we did this because we conquered our frontier by combining federal support for science with a system of free federal institutions.

We were dangerously late in developing, on our urban and industrial side, an equivalent approach to the proper role of science in society. For it was harder to bring the institutions that were the dynamic powers in that society—the great industrial corporations—into the kind of balanced relationship with the national government that had been attained between the states and the federal authorities.

But as was suggested by Vannevar Bush's metaphor—*Science, the Endless Frontier*—the new programs for government support of science may be creating a new drive and a new balance within our industrial economy. Some of our leading economists, for example, have suggested that it was only technological change, based on 20th-century research methods, which prevented the stagnation and stratification of our society after the closing of our frontier; that the discovery that enormous amounts of research could be carried on for profit was one of the most revolutionary economic discoveries of the century; and that this discovery has invalidated the Keynesian theory of investment, by continuously creating new research opportunities. Since business, however, cannot afford as much research as it would be in the interest of the entire community to have, this idea suggests that we have been saved only by the fact that a great deal of our massive military research also has civilian application (*1*).

Does this suggest that the system of government research contracts for industry may come to be the equivalent, on the urban side of our society, of the federal system of agricultural research? There were, of course, federal research programs in aid of industries before the contract system was developed. Through the National Advisory Committee on Aeronautics, for example, the Federal Government supplied the research needs of a rapidly growing new industry. But recently the NACA, transmuted into the new National Aeronautics and Space Administration, has followed the new pattern of much of the military and atomic energy research and has shifted to an approach of awarding many of its research and development contracts to private agencies.

So we now seem to be developing a system in which some of our most dynamic industries are those in which, as in agriculture, the Federal Government gives heavy support to the research needed by the entire field—and does so not mainly in its own laboratories but by contracting to support the work of private institutions, profit and nonprofit alike. The advantage to our society as a productive machine are obvious. The advantage to our society as a free political system are less obvious, but may be even more important.

For we can never again rely entirely, as some of our Jeffersonian rural ancestors did, on private property as an adequate guarantee of freedom from central authority. To preserve a balance between freedom and authority, we have been moving in the direction of operating patterns which may accomplish central policy without destroying corporate or academic independence. A university or industrial laboratory which depends in part on federal research contracts may have somewhat less independence than it had formerly, but its ability to maintain an independent point of view, and criticize central policy, is far greater than would be that of a laboratory operated entirely under government auspices. There is danger of course that this advantage, if it be one, may be purchased by a weakening of the central leadership and authority which, in certain particular fields, the needs of the next decade may require. On this issue it is too early yet to draw up the balance sheet.

A Political Force

The great danger, of course, is that this new system has been financed in the main through military channels and for military motives. But the exceptions are important. The National Science Foundation, the National Institutes of Health, and the Atomic Energy Commission and National Aeronautics and Space Administration themselves, have acquired a measure of support in their own right that gives them a degree of independence and promises continuity even in the unlikely but desirable contingency of a great lessening of international tensions. A mere two decades ago, federal support of science in private institutions was a distant dream. Today it is an established political habit—indeed, a vested interest. If I may yield to the dangerous temptation of using a scientist's term as

a political metaphor, I suspect that research as a political force has already attained its critical mass. It may not yet be a farm bloc. But there are enough people and institutions directly interested in it, and enough others persuaded of its importance, so that I doubt that even the sudden outbreak of peace on earth and good will in Moscow would have as much effect on our research as on our military budget.

But already the scientists have gone further with their processes of analysis and experimentation, with respect to governmental institutions, than most observers would have guessed. The contractual system has gone far beyond the process of buying recognized services from well-established companies or institutions. It has come to the point of creating private corporations specifically or exclusively for governmental purposes. Some of these corporations are doing work which in other countries would be considered to be at the heart of the most delicate and confidential aspects of military or diplomatic planning. The analytical approach of science could hardly go further than to break down the concept and the institutions of sovereignty to this degree. Such a far-reaching idea may lead some day to an even more radical notion; if the purposes of these new corporations are of such importance as to require administrative staffs of the highest degree of flexibility and competence, perhaps some day we will recognize that the function of creating them, coordinating them, and judging their products requires an equally high level of competence within the government. But that day is not yet with us.

Science and Freedom

My colleagues from Canada, Norway, and the United Kingdom and I have been making comparisons among institutions that are different enough but that nevertheless rest on the basis of a common assumption of freedom. All of us, however, have doubtless been making an implicit comparison not with each other and with our other free brethren but with the authors of sputnik.

All over the world people are comparing the institutions designed to assure the freedom of science with those which maintain science under a dialectic of dictatorship. It is significant, however, that at the time of the triumph of Russian technology, the prestige of communism among scientists throughout the world seems lower than it was in the days when Soviet science was still being discussed in largely theoretical terms.

Among free nations we will doubtless continue to manage our affairs and support our science in different ways. In the United States, it seems to me, our best hope is for a science which will grow, not as a guild under the patronage of a traditional sovereignty, but as a most important element in a highly diversified and free system. In this system the scientist gets his influence not from a complete detachment from politics but from sharing in the political obligations of society. And in this system, too, politics may get its strength not by meddling with the processes of research, and not by strait-jacketing science in an ideology, but by freeing science to question and improve all aspects of policy, all forms of social organization.

The economic and political system that Marx attacked is almost as obsolete as the one he envisaged. We have created something new in the United States through the influence that science has had on our society, and we are only beginning dimly to understand it. But we need to learn how to use it better if we are to continue to promote the general welfare as well as provide for the common defense. And we need to learn rapidly—to learn political wisdom and administrative competence as well as scientific ability—or there will not be any posterity to inherit the blessings of the liberty that we find so enjoyable.

Note

1. This is a layman's summary of the point of view expressed by Sumner H. Slichter in "Technological research as related to the growth and stability of the economy" [in National Science Foundation, *Proceedings of a Conference on Research and Development and Its Impact on the Economy* (Washington, D.C., 1958), p. 107].

News of Science

Power Projects for Atomic Energy Industry Examined in Annual Review by Congressional Joint Committee

Hearings on the status and future of the atomic energy industry got underway last month before the Joint Committee on Atomic Energy of Congress. More than 30 witnesses from government, industry, and other fields testified during the annual review which is required by the Atomic Energy Act of 1954. Clinton P. Anderson (D-N.M.), chairman of the committee, opened the sessions by welcoming John A. McCone on his first public appearance before the full committee since he became chairman of the Atomic Energy Commission.

Atomic Power Program

The sessions were concerned primarily with the AEC program for new power projects during the coming fiscal year. In his testimony before the committee, and in an earlier news conference, Chairman McCone said that the fundamental change for the immediate future would be a shift from a diversified program in which many alternatives are considered to a concentrated emphasis on developing those types of reactors which have shown the greatest promise. The primary concern reflected here, as the news conference indicated, is economy. Carrying a number of lines of research from theory to prototype is an exceedingly expensive process and, in an economy-minded administration, it is not something easily justified. Within this framework, the objective for the near future is nuclear power which can compete economically with that generated by fossil fuels in certain areas of the country. To this end the commission plans to have designed and under construction by the end of fiscal 1960 six experimental reactors. Three reactors will be used for experiments in cooling. The media to be tested are gas, sodium, and an organic compound made of terphenyls. This last coolant is being considered because it has a lower vapor point than water and therefore does not require the heavy

pumping and containing equipment that water does. The remaining three projects are a process heat reactor, an advanced boiling-water prototype, and a small power plant.

Congressional Response

Chairman McCone described this program as "aggressive, forward looking, and one that will get results." But before he had completed his testimony a number of committee members, including Senator Gore (D-Tenn.) and Representative Holifield (D-Calif.) began criticizing the program as "timid" and "wholly inadequate." This occasioned the first open break between McCone and the committee. A relationship which Anderson had called "very good" at the opening of the hearings deteriorated rapidly as McCone lashed back at his critics for over-hasty deprecation of his program. The exchange, which reminded many observers of the acrimony that characterized the commission-Congress relationship when Lewis Strauss was chairman of the AEC, was not taken to be a serious threat to cooperation between the two groups but just a break in the surface harmony. The fact is that the commission and the committee are in fundamental agreement on basic issues. A major aim is competitive nuclear power for some areas of the United States within 10 years. Another is power for certain European nations within 5 years.

A Question of Leadership

One issue which troubled the committee members was concerned with the commission's exact role in advancing atomic power in the United States. Chairman Anderson said he was disappointed that the commission now regarded the construction of experimental prototypes as the domain of industry. The commission now takes the responsibility for planning prototype development, but in Anderson's opinion it should also continue to build them, as it did in its earlier years. The current policy, as put forth by Chairman McCone, is to invite proposals from industry to build prototype reactors of specified types. If no satisfactory proposals are received, the commission then goes ahead and builds the reactors on its own sites. As an inducement to industry, the AEC has proposed to Congress the concept of construction grants. Under this plan, which has the approval of the Bureau of the Budget, up to 50 percent of reactor-construction costs incurred by industry could be covered by a grant.

A Question of Degree

Although the AEC and the Joint Atomic Energy Committee have no fundamental issues dividing them, questions that are primarily ones of approach remain. The major problems seem to be two: degree of leadership that the commission should exercise and size of the country's atomic power program. The commission, presumably reflecting the Administration's tight budget policy, has indicated that it prefers to give industry every opportunity to exercise some degree of leadership and, at the same time, share some of the financial burden. It would also limit development to the more promising programs. The committee, concerned less with money than with the United States Government's domestic and foreign leadership in atomic energy, is calling for a more positive governmental role and a larger program. Moves made to date, including the restoration of a canceled public power project by the AEC, indicate that, despite that initial flare-up, there is a willingness to reconcile the two differing views on leadership and size.

Desert Agriculture in Israel

A study is under way in Israel to determine whether or not it is possible to farm the Central Negev Highlands with the exclusive use of rain and floodwater, as did the ancient peoples. Michael Evenari, botanist and vice president of the Hebrew University in Jerusalem, and his wife have been living this winter in a 2000-year-old farmstead at the site of the former Nabatean city of Subeita in the Negev desert.

The farm—five terraced acres with a network of channels, spillways, and regulators—has been reconstructed, and the well-preserved five-room farmhouse has been repaired. The couple expects to stay in residence for at least 2 years, the minimum time required for crop study.

Historical Background

Extensive remains of ancient habitation and agriculture are found in the Negev desert, which covers 60 percent of the total area of Israel. Flood irrigation, ancient terracing, stone clearing, and all other phases of irrigation work were carried out with outstanding technical skill by the ancient civilizations. Archeologists have studied the general form of the civilizations that were connected with these agricultural projects, but very little, if any, field and research work has been done to understand the basic features of these agricultural systems. Even less is known about the irrigation methods, crops, and agricultural practices that enabled these farming communities to flourish in the desert.

Most of this ancient desert agriculture is concentrated in the Central Negev Highlands, which lie at an elevation of 1200 to 3000 feet above sea level and consist of rugged rocky hillsides, cut by narrow wadies leading to broad flood plains. The typical loess soil of the area forms a shallow cover on the hillsides, while in the wadi bottoms and flood plains it reaches a depth of several meters. The annual winter rainfall is sporadic and seems to fluctuate widely, with a mean between 70 to 120 mm per year (3 to 5 inches). Very little climatological data are available for the region.

The ruins of at least five large cities have been found in the area—Abda, Subeita, Auja, Kurnub, and Halutza. These cities had a total estimated population of 80,000 to 100,000 inhabitants at the peak of their development. Most of them were originally founded by the Nabateans (200 B.C. to A.D. 100) and were later expanded and developed at the time of the Byzantine Empire (A.D 300 to 700). In the vicinity of these towns, well-developed agricultural projects have been identified that date back to the same periods. Some of these projects are relatively small in size—farm units of 1 to 4 acres—while others cover from 100 to 300 acres.

Ancient Desert Agriculture

Agriculture was developed only in the depressions, wadies, and flood plains, where loess accumulated. The slopes of the hillsides served only as water collectors for providing irrigation water and also for extensive grazing. The fields in the wadi bottoms and flood plains were always terraced with strong, well-built stone walls to stabilize them and enable the runoff water to penetrate into the soil.

Only the runoff water from the hillsides was used for irrigation. This runoff is caused by even a very light rainfall, since the loess, when moistened, forms on its surface a thin crust that is almost impervious to water. This crust insures a high rate of runoff from the slopes. On the terraced fields the same crust is formed, but the leveled fields and the stone walls prevent the water from running off and it slowly penetrates into the soil.

The runoff from the hillside slopes, which was the only water source, was artificially increased by stone-clearing and exposing the soil surface directly to the action of the rain. The runoff water was directed into the fields by exploiting the natural water courses where they were impermeable. However, in those areas where the water courses were composed of permeable fissured rock or gravel, the runoff water was led to the fields through artificial conduits.

Large tracts of land in the flood plains lying adjacent to the main wadies were irrigated by means of diversion works and canals. The canals were often

a few kilometers long and several meters deep.

Preliminary investigation indicates that in all the fields the irrigation systems were so planned as to insure a complete control and distribution of the water by means of spillways, canals, drop structures, division boxes, and so forth. All these structures were built of stone. There was a depth of irrigation that would wet between 2 and 4 meters of soil. For loess, this irrigation is sufficient for the annual requirements of cultivated orchards or general field crops.

The pilot-plant farm is the culmination of years of Negev research by Evenari and his associates, South African-born Leslie Shennon, a water engineer; Naphtali Tadmore, an agriculturist; Y. Aharoni, an archeologist; and Tossi Feldman, an amateur archeologist from a nearby kibbutz, who reconstructed the farm. The research is supported by the Ford Foundation.

Evenari's preliminary findings will be reported to farmers, agriculturists, and scientists from every part of the world at the International Farmers Convention that will take place in Israel, 29 March to 12 April.

Geneva Test-Ban Negotiations

The executive committee of the Federation of American Scientists, a nationwide organization of more than 2200 scientists and engineers, has released a statement on the current nuclear test-ban negotiations at Geneva that includes the following comments.

"The present Geneva negotiations seem to be reaching a stalemate. . . . If the arms race continues, the certain spreading of nuclear weapons to more and more nations will almost surely lead to nuclear war of utter destruction.

"We should like to comment on several points of difficulty in the present negotiations.

"(1) We regret the impression given by news reports that data from the new underground explosions invalidates the inspection system worked out by the Geneva Conference of Experts last summer. Quoting from a U.S. State Department release of January 24: 'These data did not invalidate the system agreed upon at Geneva last summer.' Recently released testimony before the Senate Subcommittee on Disarmament makes it clear that the same detection capability envisioned by the Experts' Conference can be obtained with the original number of stations proposed, with some improvements in the techniques used.

"It is very unfortunate that the new seismic data were released, before thorough evaluation of the positive as well as negative aspects, in such a way as to emphasize the negative aspects of the data. The manner and form of this release was such as to give rise to misleading reports which placed undue emphasis on the negative aspects of the new data. It is understandable that in these circumstances suspicion might well arise as to the motives behind such release.

"We wish to point out that the capability and reliability of the monitoring system can be significantly improved by making use of 'calibration' explosions, both chemical and nuclear. Consequently it would be desirable that there be provision for calibration explosions in the first agreement.

"(2) The Russian insistence on veto rights over the composition and operation of the inspection teams and the technical staff which will man the stations is a clear obstacle to success of the talks. To maintain this demand certainly means blocking any hope of agreement.

"Russian insistence that monitoring stations in each country be operated only by nationals of that country is also a fundamental block to success of the talks.

"If the Russian suspicion that the detection system would be used by the West as the basis for a widespread spying system is real, other means must be found of safeguarding against espionage; this problem must not be allowed to block a nuclear policing agreement altogether.

"(3) There is a stated American desire to exclude peaceful explosions from the ban. There is in fact an American program, called Project Plowshare, which is meant to develop peaceful applications of nuclear explosions. The carrying through of the peaceful tests program is certainly less important now than is the chance of agreement on a workable test ban and its policing. If exemption of peaceful explosions from the test ban threatens the success of an agreement, Plowshare should not be insisted on. It is really extraneous to the basic issue of arriving at a better chance of peace.

"In particular, the scheduled nuclear explosions this summer under Project Plowshare could very well lead to unrestricted resumption of Russian weapons tests. No gain from Plowshare would compensate for this unfortunate result."

Tropical Medicine Survey

The National Academy of Sciences–National Research Council has announced a major survey of needs in the field of tropical medicine. The work will be directed by Willard H. Wright, recently retired chief of the Laboratory of Tropical Diseases, National Institutes of Health. Wright, who holds doctorates in veterinary medicine and in medical parasitology, was a member of the NIH staff for 22 years. He is a past president of the American Society of Parasitologists, president-elect of the American Society of Tropical Medicine and Hygiene, and has served in many capacities in the World Health Organization, for which he has just completed an assignment in the Middle East.

Advocated for several years by the American Society of Tropical Medicine and Hygiene, the survey was proposed by the Department of Defense on recommendation of the Armed Forces Epidemiological Board. Support has now been assured by the National Institutes of Health, the Department of the Army, and the Rockefeller Foundation.

As presently conceived, the investigation will cover infectious and parasitic diseases, veterinary medicine, and environmental hygiene. It will include surveys of disease problems in tropical and subtropical areas of significant importance to public health and to agricultural and industrial development; of funds expended for medical care and disease control; of financial support for research in medical and hygienic problems of the tropics; of fellowship opportunities, teaching programs, and training facilities; of career opportunities and incentives; of the impact of travel and migrations on tropical disease problems; of the importance of tropical medicine to the economy of the United States; and of projected manpower needs in terms of domestic and overseas requirements. The data assembled will be used to assess the need for domestic, foreign, and international measures to deal with the problems defined in the survey.

French Geological Information Service

The monthly publication of some 3000 to 5000 technical papers dealing with the earth sciences poses a problem of major magnitude in documentation and classification. The Service d'Information Géologique (S.I.G.) of the Bureau de Recherches Géologiques, Géophysiques et Minières (B.R.G.G.M.) is attempting to cope with this problem by means of a classified card index, duplicated for sale to interested persons or institutions. The index provides ready reference by means of letters and numbers, to 1200 subjects, the main headings being mineralogy, petrography, stratigraphy, tectonics, geophysics, general and dynamical geology, applied geology, history and activities of geology, regional geology, general paleontology, biology, botany, and zoology, prehistory and problematica.

Full information, descriptive data, and samples of work may be obtained from J. Roger, B.R.G.G.M., 74 Rue de la Fédération, Paris 15, France.

Senate Subcommittee on Space

Senator Lyndon B. Johnson, chairman of the Senate Space Committee, has announced the establishment of a new subcommittee to investigate "wasteful rivalry and duplication" in space programs. It will be headed by Senator Stuart Symington (D-Mo.), a strong critic of Administration defense policies. Other senators on the seven-man subcommittee, which will start hearings and issue recommendations as soon as possible, are Thomas J. Dodd (D-Conn.); Howard W. Cannon (D-Nev.); Stephen M. Young (D-Ohio); Styles Bridges (R-N.H.); Margaret Chase Smith (R-Me.); and Clifford P. Case (R-N.J.).

High-School Science Demonstration-Lectures

Next fall scores of teachers, trained during the coming summer with the support of the National Science Foundation, will travel widely among secondary schools throughout the nation to stimulate student interest in science by providing science demonstration-lectures. During the summer groups of high-school science teachers will receive 3 months of special instruction in physics, chemistry, biology, and mathematics at four training centers—Michigan State University, Oklahoma State University, the University of Oregon, and the Oak Ridge Institute of Nuclear Studies. The University of Oregon training will include, in addition to the basic subjects, emphasis on those scientific topics of special interest to the Northwest.

The foundation estimates that teachers sponsored by the program will visit 3000 secondary schools during the year. To defray costs of the teachers' salaries, equipment, and travel, and the costs of selecting and training teachers, the NSF has made grants of $349,700 to Michigan State University; $335,700 to Oklahoma State University; and $382,000 to the University of Oregon. Each university will select candidates from among applicants who, in general, are teaching in states representing the region which centers around the university.

Two grants, totaling $531,600, to the Oak Ridge Institute of Nuclear Studies, cover expenses of (i) the regular summer-training program for 20 teachers selected by Oak Ridge from the Southeast; (ii) a special summer-training program for 20 teachers nominated by various states, under the terms of which teachers will return to the states from which they are nominated; and (iii) two additional training programs for 20 teachers each, also nominated by several states, one to begin in the fall of 1959, the other in the spring of 1960.

The expanded program for the 1959–60 academic year is an outgrowth of a successful experimental demonstration-lecture program for seven teachers begun in 1956–57, and continued in 1957–58 with the establishment of a training center at Oak Ridge, sponsored jointly by the foundation and the Atomic Energy Commission. Concurrently with the lecture-demonstration training, the traveling teachers designed and built many pieces of apparatus for use in their subsequent visiting lectures. Many of these inexpensive "homemade" assemblies were used as models which later were duplicated by secondary-school teachers working with their students.

During the 1957–58 school year the traveling teachers made 1-week visits to 260 high schools throughout the country. They gave lecture-demonstrations during the day in the schools and were usually invited to provide extra lectures for parent and civic groups. In addition to the schools visited formally, other neighboring schools often served as hosts while the teacher was in the community, so that 892 schools (including some elementary schools) received at least one demonstration-lecture. More than 226,000 high-school students and some 5700 high-school teachers were reached in the 1957–58 program.

Applications for the 1959–60 Science Demonstration-Lecture Program should be sent to the appropriate program directors. They are as follows: Dr. Frederic B. Dutton, Science and Mathematics Teaching Center, Michigan State University, East Lansing, Mich.; Dr. W. W. Grigorieff, Chairman, University Relations Division, Oak Ridge Institute of Nuclear Studies, Inc., P.O. Box 117, Oak Ridge, Tenn.; Dr. Harry Alpert, Dean, Graduate School, University of Oregon, Eugene, Ore.; and Dr. Robert C. Fite, Director of Arts and Sciences Extension, Oklahoma State University, Stillwater, Okla.

Experimental Radar

Lincoln Laboratory of the Massachusetts Institute of Technology is operating a new experimental high-power search radar on Boston Hill in North Andover, Mass. The facility is the direct result of experimental work on a less powerful installation at Jughandle Hill, Bath, Me., which has now become a part of the experimental sector of the SAGE Air Defense System.

Lincoln Laboratory is engaged in electronic research on problems of air defense and is supported by the Army, Navy, and Air Force. Lincoln's tri-service contract is administered by the Air Research and Development Command of the Air Force through the Air Force Cambridge Research Center in Bedford, Mass.

Massachusetts Institute of Technology experimental radar.

Even though the antenna assembly weighs more than 50 tons, it can be rotated at speeds up to 5 revolutions per minute in winds of 60 miles per hour and still maintain an accuracy of less than 0.1 degree. The reflector measures 120 feet wide and 30 feet high; it is 50 percent larger than the next largest of its type in operation.

In order to assure long life with continuing accuracy for such a large antenna, extensive effort was devoted to the design and fabrication of the bearing and structure on which the antenna is mounted. The four-point-contact azimuth bearing is the largest integral gear and ball bearing yet installed. It is 13½ feet in diameter and contains 110 3-inch bearings matched to 0.0001 inch.

The output or power tube of the transmitter is a 10-foot klystron that was constructed under Lincoln Laboratory sponsorship for use in this radar.

News Briefs

The United Nations Scientific Committee on the Effects of Atomic Radiation will begin its sixth session at UN Headquarters on 23 March. The main business of the session is expected to be consideration of the committee's future work as a consequence of a resolution on effects of atomic radiation adopted unanimously by the UN General Assembly in December 1958.

The resolution, among other things, commended the committee for the report it submitted in mid-1958 regarding the effects of atomic radiation; requested the committee "to continue its useful work and report to the Assembly as appropriate"; asked the committee to consult with other agencies and organizations concerned to insure effective coordination of activities; and requested the Secretary-General to continue to provide the committee with assistance.

* * *

An interagency research advisory committee has been formed by representatives of the Alaska Department of Health, Alaska Native Health Service (U.S. Public Health Service), Arctic Aeromedical Laboratory (U.S. Air Force), and Arctic Health Research Center (U.S. Public Health Service) to assist scientific investigators in medical and allied fields who wish to perform research in Alaska. The committee is prepared to assist investigators sponsored by a recognized institution by explaining local situations, in meeting logistic difficulties, and making Alaskan facilities available. Persons desiring such assistance should write to E. M. Scott, Chairman, Interagency Research Advisory Committee, Arctic Health Research Center, Box 960, Anchorage, Alaska.

* * *

Announcement has been made by the National Academy of Sciences–National Research Council that the committee on animal care of the Institute of Laboratory Animal Resources, after consultation with various professional societies and research workers, has proposed certain general principles for the treatment and use of animals in laboratories and schools. *Principles of Laboratory Animal Care* is intended for workers in universities and industries, and *Guiding Principles in the Use of Animals by Secondary School Students and Science Club Members* is directed to students and science teachers. Reprints of both statements are available from the Executive Secretary, Institute of Laboratory Animal Resources, National Research Council, 2101 Constitution Avenue, NW, Washington 25, D.C.

* * *

A record 94,400 full-time university-grade students were in attendance at Canadian universities and colleges on 1 Dec. 1958, some 9.1 percent above the 1957–58 total of 86,500, according to advance figures released by the Dominion Bureau of Statistics.

New peaks in enrollment were established in the current academic year in the four Atlantic provinces and in Quebec, Alberta, and British Columbia, while enrollment in Ontario and Saskatchewan was approaching the record set in the 1947–48 session.

A private collection of moths and butterflies native to the United States—the results of a lifetime devoted to the task of collecting examples of the more than 5000 known species—has been acquired by the American Museum of Natural History.

The collection of the late Otto Buckholz of Roselle Park, N.J., numbering 125,000 specimens and including approximately 95 percent of the more than 5000 species of butterflies and the larger moths found in this country, has been purchased by friends of the museum for the department of insects and spiders. The collection will be available for study by scientists and students.

Grants, Fellowships, and Awards

Agricultural chemistry. The Association of Official Agricultural Chemists has announced that nominations are now being accepted for the third AOAC Harvey W. Wiley Award for Achievement in Analytical Methods. This $500 award goes to the scientist who makes an outstanding contribution to the development of methods of analysis for foods, drugs, cosmetics, feeds, fertilizers, and pesticides, or for use in general analytical chemistry. Nominations must be submitted *by 1 April.* Nominees need not be members of the association. Further information may be obtained from the secretary, William Horwitz, Box 540, Benjamin Franklin Station, Washington 4, D.C.

Biological sciences. The Division of Biological and Medical Sciences of the National Science Foundation has announced that the next closing date for receipt of basic research proposals in the life sciences is *15 May.* Proposals received prior to that date will be reviewed at the summer meetings of the foundation's advisory panels, and disposition will be made approximately 4 months following the closing date. Inquiries should be addressed to the National Science Foundation, Washington 25, D.C.

General. The Karl P. Schmidt Fund has modest sums available to assist persons wishing to study at the Chicago Natural History Museum. Grants will be made for study in any of the four fields encompassed by the museum: anthropology (with a natural history orientation), botany, geology (including paleontology), and zoology. An applicant should describe the study proposed in brief terms, state the length of time he wishes to study at the museum and the amount of money needed, and name one reference. Applications should be mailed to: Chairman, Karl P. Schmidt Fund, Chicago Natural History Museum, Roosevelt Road and Lake Shore Drive, Chicago 5, Ill.

Scientists in the News

President Eisenhower has named five scientists to his 18-member Science Advisory Committee. The new appointees, four of whom are replacements, are as follows:

EMANUEL R. PIORE, physicist and electronics engineer and director of research for International Business Machines.

CYRIL S. SMITH, professor of metallurgy at the University of Chicago, and member of the General Advisory Committee of the Atomic Energy Commission.

GLEN T. SEABORG, Nobel Prize winner and professor of chemistry at the University of California.

BRITTON CHANCE, biophysicist and director of the Johnson Foundation of the University of Pennsylvania.

JOHN BARDEEN, professor of physics and electrical engineering at the University of Illinois.

Lord PLOWDEN, chairman of the United Kingdom Atomic Energy Authority, recently visited U.S. atomic energy installations on invitation by John McCone, chairman of the U.S. Atomic Energy Commission. McCone and Willard F. Libby, AEC Commisisoner, visited Britain's principal atomic power and research centers in November of last year.

WILLARD F. LIBBY, scientist member of the Atomic Energy Commission, has been appointed professor of chemistry at the University of California, Los Angeles.

IRA H. ABBOTT, assistant director of research (aerodynamics and flight mechanics), National Aeronautics and Space Administration, has been appointed deputy director of aeronautical and space research. He will continue to serve in his present position as well.

D. W. JUENKER, assistant professor of physics at Notre Dame University, has received the 1958 Young Author Award of the National Association of Corrosion Engineers for a paper on "Cavity Formation in Iron Oxide" that he wrote in collaboration with R. A. Meussner and C. E. Birchenall.

THOMAS M. HAHN, JR., head of the department of physics at Virginia Polytechnical Institute, has been appointed dean of arts and sciences at Kansas State College, effective 1 September.

FRANK H. T. RHODES, head of the department of geology at University College, Swansea, Wales, will be a

visiting professor at the University of Illinois during 1959. He will be a staff member of the university's geology field camp in Wyoming during the summer and will teach graduate and undergraduate paleontology courses on the Urbana campus in the fall.

DONALD M. HENDERSON, mineralogist in the department of geology at the University of Illinois, will be at Swansea this year on a Guggenheim fellowship.

ROBERT S. STONE, chairman of the department of radiology at the University of California School of Medicine, Berkeley, has been awarded the gold medal of the American College of Radiology.

KENNETH E. PENROD, professor of physiology and assistant dean of the Duke University School of Medicine, has been named coordinator of the new Medical Center at West Virginia University, Morgantown, effective 1 July.

SAMUEL ZWERLING, associate surgeon at Brooklyn Eye and Ear Hospital, has been appointed professorial lecturer in otolaryngology at the State University of New York Downstate Medical Center, Brooklyn.

R. D. HOOGLAND, senior research officer, C.S.I.R.O.'s Division of Land Research and Regional Survey, Papua–New Guinea Survey, Canberra, arrives on 21 March to conduct research in plant taxonomy. He will visit Boston, New York, Washington, and San Francisco, and will leave this country on 16 April.

Scientific visitors to the United States from the United Kingdom are as follows:

B. EDMONDSON, senior scientific officer, Metallurgy Division, National Physical Laboratory, Teddington, Middlesex, has been invited by the U.S. National Academy of Sciences to attend a Conference on Fracture to be held in Swampscott, Mass., from 12 to 16 April. He will also visit Washington (20 and 21 April), Pittsburgh, and Schenectady. He will leave the country on 25 April.

S. R. PELC, scientific staff member of the Medical Research Council's Biophysics Research Unit, King's College, London, arrived on 16 March by invitation of the American Cancer Society to spend a year at the Cancer Research Institute of the University of California Medical Center, San Francisco.

ROGER SMITH, member of the Medical Research Unit, University College of the West Indies, Mona, St. Andrew, Jamaica, will visit pediatric centers and laboratories in Boston, New York, Philadelphia, and Washington from 5 to 25 May.

Australian scientific visitors to the United States include the following:

A. L. C. WALLACE, research officer, Commonwealth Scientific and Industrial Research Organization's Division of Animal Health and Production, Sheep Biology Laboratory, Prospect, N.S.W., arrived 1 March for a month's tour in the United States. He will leave for Canada on 1 April, and for London on 6 April.

THELMA M. REYNOLDS, senior research officer, C.S.I.R.O.'s Division of Food Preservation and Transport, Organic Chemistry Investigation, Homebush, N.S.W., arrives on 29 March to take part in the annual meeting of the Institute of Food Technologists in Philadelphia. She will leave for England in April and return to this country on 11 May to stay until 13 June. Her itinerary includes Davis, Berkeley, Pasadena, and San Francisco, Calif.; New York, Philadelphia, and Washington, and Peoria, Ill.

MELVIN M. UDEL of the department of occupational medicine, Columbia University School of Public Health and Administrative Medicine, has been appointed director of safety and occupational health at the Metropolitan Life Insurance Company, New York.

VERO C. WYNNE-EDWARDS, Regius professor of natural history, Marischal College, University of Aberdeen, Scotland, will be on leave during the second semester of 1958–59 to serve as visiting professor of conservation in the department of biology, University of Louisville, Ky.

S. DILLON RIPLEY, assistant professor of zoology at Yale University and faculty member since 1946, has been appointed director of Yale's Peabody Museum. The appointment will be effective 1 July upon the retirement of CARL O. DUNBAR, who has been director of the museum for 16 years. Ripley is also president of the International Council on Bird Preservation.

JOHN WURDACK, associate curator of the New York Botanical Garden, and LINCOLN ADDERLY, of the gardening department, will collect flora of the rainy season along the upper Orinoco River in Venezuela. The expedition, which will last from April through August, has been made possible by the New York Botanical Garden and the Servicio Botanico of the Venezuelan Government.

Recent Deaths

DANA B. CASTEEL, Austin, Tex.; 81; retired in 1952 as professor of zoology at the University of Texas, which he joined in 1909 as an instructor; chairman of the department of zoology from 1913 to 1915 and from 1925 to 1947; 10 Feb.

ABBOTT C. COMBES, Jr., Sheffield, Mass.; 74; head of the Combes Sanitarium for Mental and Nervous Diseases, New York, from 1914 to 1935; had been on the staff of Flushing Hospital, Queens, and had served as a division surgeon for the Long Island Railroad; 27 Feb.

ELIZABETH M. DACH, New York; formerly information specialist with the National Institute of Mental Health, Washington, D.C.; 25 Feb.

JAMES F. HART, New York; 73; adjunct professor of medicine at New York University Medical School and director of metabolism at Midtown Hospital; former associate clinical professor of medicine at the New York Medical School; 24 Feb.

DENIS C. McGENTY, New York; 50; director of professional education for the National Council on Alcoholism; taught sociology at the universities of Minnesota and Notre Dame and at DePaul University; conducted workshops in human relations at the University of Chicago and Northwestern University; 28 Feb.

GOTTWALD SCHWARZ, New York; 78; radiologist; professor of radiology at the University of Vienna, and director of radiology at Elizabeth Hospital in Vienna, Austria, until 1941, when he came to the United States; author of more than 170 papers, including one paper in 1903 on the effect of radiation on the nucleus of living cells; 26 Feb.

DAVID STEIN, Philadelphia, Pa.; 58; physician and former teacher at Temple University Medical School; 25 Feb.

LYNDE P. WHEELER, Roanoke, Va.; 84; chief of the Technical Information Division of the Federal Communications Commission from 1936 until his retirement in 1946, after which he became consulting physicist with Pickard and Burns, Inc. until 1956; consulting physicist at the Naval Research Laboratory, 1933–36; associate professor of physics at Yale University; 1923–36; 1 Feb.

LEWIS M. WOOD, Toronto, Canada; 76; until retirement in 1946, he was president of the Canadian National Institute for the Blind for 36 years; one of the founders of the National Society of the Deaf and Hard of Hearing, of which he was president, and the Canadian Paraplegic Association; 2 Mar.

Book Reviews

Education and Freedom. H. G. Rickover. Dutton, New York, 1959. 256 pp. $3.50.

Conant says that there's nothing wrong with the American high schools that a few changes will not correct [*The American High School Today* (McGraw-Hill, New York, 1959); reviewed in *Science* **129**, 382 (1959)]. Rickover wants a brand new deal. He believes that the high-school curriculum is watered down; too many high-school teachers are not qualified for their jobs; much time is being wasted; excellence in teaching is yielding to mediocrity; badly needed human talent is being lost; our schools are inferior to those of the Russians (who abandoned John Dewey to copy the European system); we need demonstration schools (European model) to revolutionize our educational system by setting up bench marks of excellence—bench marks that will lead to national standards for the certification of teachers and to a series of comprehensive examinations for measuring the achievements of high-school seniors before they are graduated.

Conant identifies the comprehensive high school as a uniquely American contribution in the Anglo-Saxon tradition. Thus, he elicits in this country a flood of warmth and receptivity. Rickover, on the other hand, paints a harsh picture of the villain in the piece—a revered American philosopher who so misled American educators and administrators as to give rise to a new species called "educationists." These must first be destroyed if our country is to survive. In easy stages, Rickover's advocacy of Russian (European) education assumes a non-American look which soon becomes un-American in its projected image. As Max Lerner says, "If Rickover were clearer about education *for* freedom, he would be much more savage than he is about the Russian educational system."

Conant and Rickover are seeking many similar goals, but in ways that are contrastingly different. Some of Conant's recommendations call for educational upheavals as radical as any which Rickover is advocating. One example is the proposal to reduce the number of secondary schools so that all of them can have at least 100 students in the senior class. In my humble opinion this may take a century of effort, if it can be done at all. Furthermore, we need 400 or 500 in the senior class to do the job for the academically talented that needs doing, unless we are ready to spend at least twice as much money for education as we are presently willing to spend. Rickover would give his blessing to any device which would make classes more homogeneous with respect to ability but would probably be impatient with, and suspicious of the efficacy of, the "comprehensive" features of the high school.

I regret Rickover's passionate impatience because I prefer his overhaul job to a mere tinkering with the educational system. If we are impressed by the seriousness of the world picture Rickover paints, then we must admit that we are at war in a struggle for the survival of all that is dear to us. No half measures will do. I wish Rickover had not seen fit to attack Dewey when he was really attacking Dewey's interpreters. I wish he had not glamorized the European educational system to an extent not necessary to make his essential points. In doing so, he precipitates arguments from the opposition that are as *ad hominem* as his own. While Rickover's interest in education may have originated in dissatisfaction with the education of the men he sought for work on the *Nautilus*, one must admit that his understanding of the history of education is superb. Certainly, he has traced with force and clarity the debt we owe to the best in Greek and Roman culture.

Weighing all in the balance, I must side with Rickover. The time has come when we can no longer afford to paralyze action in educational reform. Talent *is* being wasted. We *are* falling behind the Russians. Our high schools need *more* devotion to excellence. Equal educational opportunity is *not* the same as equal educational exposure. Heterogeneous classes *do* tend toward mediocrity. The sights *must* be raised for all our students—bright, average, and slow. Not all scholars are good teachers, but good teachers must first be scholars. The action of good mind upon good mind in classrooms *does* promote learning in ways never dreamed of it. It is *not* undemocratic to organize schools with classes that are more nearly homogeneous in interest and ability. Special schools, where it is feasible to establish them, *are* most potent instruments for excellence in teaching and in learning. The essence of democracy *must* be to let each child become all that he is capable of being.

Whether Conant's gradualism or Rickover's revolution prevails depends in the last analysis upon the progress of the cold war. The hotter it gets, the sooner we will move in the direction toward which Rickover leads.

MORRIS MEISTER
Bronx Community College, New York, New York

Foundations of Modern Physical Science. Gerald Holton and Duane H. D. Roller. Duane Roller, Ed. Addison-Wesley, Reading, Mass., 1958. xvi + 782 pp. Illus. $8.50.

Physics. Henry Semat and Robert Katz. Rinehart, New York, 1958. viii + 927 pp. Illus. $9.

Physics for Engineers and Scientists. Richard G. Fowler and Donald I. Meyer. Allyn and Bacon, Boston, Mass., 1958. xiii + 546 pp. Illus. $8.

Principles of Modern Physics. A. P. French. Wiley, New York; Chapman and Hall, London, 1958. ix + 355 pp. Illus. $6.75.

Introduction to Modern Physics. C. H. Blanchard, C. R. Burnett, R. C. Stoner, R. L. Weber. Prentice-Hall, Englewood Cliffs, N.J., 1958. xi + 414 pp. Illus. $10.

The first three books listed above deal with elementary physics—that is, first-year college physics; the last two are for more advanced students. Each book has a different outlook and general method, and the existence of these differences is an indication of the different reasons for teaching and studying physics in college today.

The Foundations of Modern Physical Science, by Holton and Roller, is intended, according to the authors, "mainly for courses of two types: (a) the one-year general physics course for science majors (including premedical students) outside physics and engineering, and (b) the course for majors in the humanities and social studies, including the physical science course for liberal arts students and the integrated or general education course." The approach to the study of physical science is the same as in Holton's well-known

textbook, *Introduction to Concepts and Theories of Physical Science,* but in the present book the mathematical and conceptual material are developed more extensively, and there is more material on physical optics, electricity and magnetism, and nuclear physics. The newer book does not replace the older one but provides a differently weighted treatment. As in the older book, there is great emphasis on the basic concepts and theories, on their historical development, and on the relationship between theory and experiment. The nature of scientific thought and discovery is carefully explained and elucidated, and the material is organized according to the historical and philosophical development of physical science.

There are nine parts: "The study of motion"; "The study of forces"; "The study of planetary systems"; "On structure and method in physical science"; "The conservation principles"; "Origins of atomic theory in physics and chemistry"; "Theories of fields in electricity and magnetism"; "The quantum physics of light and matter"; and "The nucleus."

The book is excellently organized and written, and I found it a pleasure to read. It could be read with profit by physics specialists, who too often learn little about the philosophical aspects of science while they are mastering the techniques, and it could well be used to supplement the more specialized texts used in courses for physics and engineering majors. At the same time, the technical exposition is very well done; there are many good examples and problems, and students should learn a good deal of basic physics from the book.

Physics, by Semat and Katz, is intended for students of science and engineering; according to the authors, "it aims to develop both an understanding of the important concepts of physics and some analytical skill in the solutions of problems. The mathematical level . . . is such that it may be used by students who are taking a course in calculus concurrently." Thus, calculus and vector analysis are used throughout. The subject matter is divided into six parts—"Mechanics," "Heat," "Wave motion and sound," "Electricity and magnetism," "Optics," and "Atomics and nucleonics."

In view of the fact that Semat is one of the authors it is not surprising that the book is an excellent one. The exposition is clear; the coverage is complete and thorough; the figures and diagrams are plentiful and helpful; and there are many good problems and modern examples. As one who works in the field of Nuclear Engineering, I found the treatment of units especially appealing. In the sections on mechanics, heat, and sound, the British engineering system and the centimeter-gram-second and meter-kilogram-second metric systems are used; in the section on electricity and magnetism, the rationalized meter-kilogram-second system is the main one used, but the unrationalized Gaussian system is also developed because of its wide use. There are very helpful tables of equations and conversion factors for the various units used in electricity and magnetism. The treatment of atomic and nuclear physics is particularly good for those students who will not go on to a separate course in these subjects.

Physics for Engineers and Scientists, by Fowler and Meyer, was written, according to the authors, in response to "the present-day pressure by colleges of engineering for reducing the purely engineering content of general physics as it is commonly taught and increasing the attention given to modern physics." Instead of following the traditional division of physics into mechanics, heat, wave motion and sound, and so forth—as, for example, in the book by Semat and Katz—the authors attempt a more unified treatment, in which atomic and molecular concepts are introduced, as is electricity, much earlier than in most physics textbooks. Vectors and calculus notation are used throughout, but formal calculus manipulations are presented in such a way that they may be omitted by students who have insufficient mathematics. The result is a book which has less detail and is less thorough than that by Semat and Katz (it is shorter by about 400 pages) but which is more homogeneous in its treatment. The figures are excellent, and there are many helpful examples and problems.

I do not have enough experience in the teaching of elementary physics to compare the effectiveness of this treatment with that of the traditional kind of presentation, but the treatment is certainly an interesting one, and one which should appeal to many teachers and students.

The books by French and by Blanchard *et al.* are two more attempts to meet the increasing need on the part of scientists and engineers for a mastery of the concepts and methods of modern physics. French's *Principles of Modern Physics* traces the development of the concepts and theories of modern physics; the author has tried "in the space available to trace the progress of some of our more important physical concepts with the help of a minimum of detailed information." The chapter headings indicate the scope of the book: "The atomic theory of matter," "Light and the electro-magnetic field," "The atomicity of electric charge," "Thermal radiation and the quantum theory," "Quanta and atoms," "Relativity," "Wave mechanics," "Some applications of quantum mechanics," and "The nucleus."

The author has succeeded very well in his aims and has produced a clear, logical, and consistent account of the basic ideas of modern physics. The interrelation between theory and experiment is clearly brought out, and enough examples are given to show how the concepts are used. The style is laconic, and there is no danger that the student will miss the forest for the trees; with some collateral reading (and there is an adequate bibliography for each chapter), French's book will provide science students with a sound introduction to modern physics.

Introduction to Modern Physics, by Blanchard, Burnett, Stoner, and Weber, stems from a required course in atomic and nuclear physics in the engineering curricula at Pennsylvania State University. The direction and speed of technical development in the modern world make a course of this type essential for engineering students, and this book should be a good text for such a course. The scope is somewhat broader than that of French's book, and more applications are included. In addition to the subject matter covered by French, there are chapters on "Molecules and solids," "Ranges absorption and detection," "Nuclear reactions," "Applications of nuclear physics," and "High-energy research." The treatment is less deep and less critical than that of French, but the greater breadth should serve to provide a satisfactory background in modern physics for future engineers. The book is clearly written and has a good supply of examples, problems, and references.

IRVING KAPLAN
Department of Nuclear Engineering, Massachusetts Institute of Technology

Mental Subnormality. Biological, psychological, and cultural factors. Richard L. Masland, Seymour B. Sarason, and Thomas Gladwin. Basic Books. New York, 1958. 442 pp. $6.75.

In the last two decades, with the decrease in incidence and urgency of the acute infectious disorders, the enormous toll exacted by the chronic disorders has been bared. Of these, the large group of conditions included under the rubric of mental subnormality (depending upon definition, 3 to 14 percent of the population are included in this group), is by far the most costly to society and the individual affected. The problems of research, prevention, and care are apparently so overwhelming that the entire area has been and is badly neglected. However, the increasing concern of governmental and private agencies, as well

as the country as a whole, promises much for the future.

Under the auspices of certain of the national, private, and public health foundations and institutes concerned with the problem, Masland, Sarason, Gladwin (neuropsychiatrist, psychologist, and anthropologist, respectively) were commissioned to review critically the past and present research and thinking in the vast field of mental subnormality. The authors were not only to examine and cull the good work from the mass of poorly conceived and conducted studies of past generations, but also to integrate their findings into a meaningful whole, and in addition, to discuss the promising leads for future research. This volume is the result of 2 years of intensive work.

Interestingly enough, Masland, who summarized the prenatal and postnatal organic causes of mental deficiency, has titled his part "The Prevention of Mental Subnormality." Sarason and Gladwin enter upon the usually disconcerting effort of defining intelligence and then go on to an intensive discussion of the relationships of psychological and sociocultural variables to intellectual functioning. In this extensive review of years of effort by thousands of individuals, the authors have managed to produce a coherent, lucid, and eminently usable account of a large number of heterogeneous conditions which are multivariably caused and which may be related or unrelated. The authors come to no single or simple conclusion. However, beginning with quite different frames of reference, they "take very different avenues to attack a single worrisome and damaging concept, that of a hereditary taint as the basis for all mental subnormality. The attempt to lay this shibboleth finally to rest is implicit in much of both reports." It was apparent to the collaborators, as the attribution of etiological factors became increasingly specific and valid, that geneborne disorders had been frequently offered on a *post hoc* basis.

The attempt to unravel and specify established and likely causations, separately and in combination, becomes the theme of the book, and it must be acknowledged that the authors have performed exceedingly well an almost impossible task. Illustrative of the magnitude of this massive effort is the fact that each one of the over 600 references given has been used at least once and frequently many times in the structure of their argument and has not been inserted as padding—a too-common occurrence in academic work. It is, therefore, not too surprising that a number of annoying bibliographic errors are found when attempts to trace specific references are made. There are a few errors in quotation or interpretation as well as over- and underemphasis. The authors, themselves, are aware that they have not given sufficient effort to the integration of the interplay of organic, psychological, and social factors. It would be surprising in a work occupied with every level of integration from nuclear physics to culture if some errors could not be found to criticize. These can be left to succeeding editions for correction, and there would appear to be little doubt that succeeding editions will be forthcoming in view of the obvious and critical need for the book. This is a nodal piece of work in the field of mental subnormality. Its definitiveness and its stimulating and exciting qualities make it all the more valuable. It will be widely read and discussed, and it should be the fervent hope of all who work in the area of mental health that its implications and recommendations will be widely disseminated.

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The American Labor Force: Its Growth and Changing Composition. Gertrude Bancroft. Wiley, New York; Chapman and Hall, London, 1958. xiv + 256 pp. Illus. $7.50.

Following the 1950 United States census, several studies, entitled the *Census Monograph Series,* were prepared under the auspices of the Social Science Research Council in cooperation with the U.S. Bureau of the Census. These studies considered such topics as the changing population of the United States, American families, and urban and rural areas.

The American Labor Force is a volume in this series. By *labor force* is meant the total number of persons reported as employed, plus the unemployed—that is, persons so reported to the census enumerator at the time of the 1950 census (or at the time of the pertinent monthly sample survey of the population).

Bancroft's study is largely concerned with analyzing the statistics provided by the census of 1950 and earlier censuses supplemented by data from the Census Bureau's monthly sample surveys. She deals with selected aspects of the measurement, growth, and composition of the labor force. Chapter 1 describes the United States labor force as of 1956; some additional material about persons not in the labor force—that is, the nonworkers—is included. Chapter 2 describes trends in the labor force from 1890 to 1955, giving the numbers and proportions of persons engaged in various occupations, together with brief mention of changing occupational patterns. Chapter 3, the longest in the book, contains an exhaustive and detailed analysis of changes between 1940 and 1950—changes in labor force participation from the standpoint of age, color, marital status, and so forth.

Trends in the part-time labor force (chapter 4) and family employment patterns (chapter 5) are two topics which have been seriously neglected in past analyses of the labor force. This resulted in part from the lack of statistics which would permit study of these topics and in part from undue preoccupation with the individual worker rather than interest in the family as a working entity. Bancroft has brought together many data, most of which have become available only since the end of World War II, and has obtained some interesting findings, such as, "there is not much reason to believe that 'that interesting part time job' which is the goal of so many better educated women has become a very common feature of the present labor market" (page 107). More definitive analysis of these two interrelated topics, unfortunately, will have to await the availability of more statistics and information. The reader who is interested in these two topics should also see Paul Glick's *American Families,* another volume in the *Census Monograph Series.*

Projections of the labor force to 1975 are given in chapter 6. Four methodological appendices complete the volume.

On the whole, this is an excellent census type analysis, in line with the presentations in other volumes of the series. I feel, however, that the inclusion of more noncensus material and analyses (of which there is a considerable body available) would have given more breadth and scope to the findings and, indeed, would have strengthened them.

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On the Magnet. William Gilbert. A volume in the "Collector's Series in Science." Derek J. Price, Ed. Basic Books, New York, 1958. xi + 247 pp. $8.50.

The period between the mid-16th and mid-17th centuries was one of great creative activity in the field of natural philosophy. A number of investigators took a fresh look at the world about them and sought not only to comprehend that world but to apply the newly gained understanding.

One of these men was William Gilbert, Elizabethan physician and student of the loadstone. His findings were incorporated in *De Magnete,* first published in London in 1600. Basic Books

has reprinted the English edition of S. P. Thompson, the well-known author of many 19th-century texts on electrical engineering, and D. J. Price of the Institute for Advanced Study has contributed a biographical introduction.

The appearance of this book has added another important work from the history of science to the growing list of reprints. It is a highly commendable selection and one that should do much to change the status of the book from that of a classic that is commonly quoted but infrequently read to one whose significance is justly appreciated.

JAMES KING

Division of Electricity,
Smithsonian Institution

The Chemical Analysis of Food and Food Products. Morris B. Jacobs. Van Nostrand, Princeton, N.J., ed. 3, 1958. xxiv + 970 pp. Illus. $13.75.

The new edition of this well-known book contains 69 pages of new material, divided between consideration of analytical methods for radioactive materials, pesticide residues, and artificial sweetening agents. The original material of the other chapters has been retained substantially intact. In a few cases where radical revision has been required (for example, with reference to coal-tar colors and to coumarin), the necessary changes in text have been accomplished without altering the original pagination.

The revision appears to me to be somewhat less thorough than the publisher states, particularly in a field developing as rapidly as this one.

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New Books

Biochemistry and the Central Nervous System. Henry McIlwain. Little, Brown, Boston, ed. 2, 1959. 295 pp. $10.

Canadians in the Making. A social history of Canada. Arthur R. M. Lower. Longmans, Green, Toronto, Canada, 1958. 499 pp. $7.50.

Celestial Mechanics. E. Finlay-Freundlich. Pergamon, New York and London, 1958. 158 pp. $7.50.

Čerenkov Radiation and Its Applications. J. V. Jelley. Pergamon, New York and London, 1958. 314 pp. $10.

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Electromechanical Energy Conversion. David C. White and Herbert H. Woodson. Wiley, New York; Chapman & Hall, London, 1959. 661 pp. $12.50.

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The Family Medical Encyclopedia. Justus J. Schifferes. Little, Brown, Boston, 1959. 636 pp. $4.95.

Fundamentals of Ecology. Eugene P. Odum. Saunders, Philadelphia, Pa., ed. 2, 1959. 564 pp.

The Magneto-Ionic Theory and Its Applications to the Ionosphere. J. A. Ratcliffe. Cambridge Univ. Press, New York, 1959. 217 pp. $7.50.

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Physiology of Muscular Activity. Edward C. Schneider. Peter V. Karpovich, Ed. Saunders, Philadelphia, Pa., ed. 5, 1959. 385 pp.

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The Theory and Design of Magnetic Amplifiers. E. H. Frost-Smith. Wiley, New York, 1958. 506 pp. $12.50.

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Tree Maintenance (originally published as *Maintenance of Shade and Ornamental Trees, 1941*). P. P. Pirone. Oxford Univ. Press, New York, 1959. 501 pp. $10.

Viral and Rickettsial Infections of Man. Thomas M. Rivers and Frank L. Horsfall, Jr., Eds. Lippincott, Philadelphia, Pa., ed. 3, 1959. 985 pp. $8.50.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, *but to the publisher or agency sponsoring the publication.)*

Joint FAO/WHO Expert Committee on Nutrition. Tech. Rept. Ser., No. 149. World Health Organization, Geneva, Switzerland, 1958. 55 pp. $0.60.

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Reports

Ascites Induced in Mice by Staphylococcus

Abstract. Ascitic fluid containing high titers of antibody was induced in mice by *Staphylococcus*. Two to three intraperitoneal inoculations of 0.3 ml of a killed suspension of *S. aureus* mixed with complete Freund's adjuvant, given at 5-day intervals, produced ascites in 100 percent of the mice tested.

An adequate supply of potent antibody is indispensable for studies in basic immunology. This report describes a method for producing ascitic fluid containing high titers of antibody against *Staphylococcus aureus* strain 18 in mice (*1*).

Munoz, using paraffin oil mixed with *Mycobacterium phlei* as an adjuvant and egg albumin or bovine serum albumin as the immunizing agent, produced ascitic fluid containing good antibody titers in 50 percent of the mice tested (*2*). Herrmann and Engle, using sarcoma 180 cells and influenza A and Newcastle disease viruses, produced ascitic fluid in mice containing antibodies against these viruses (*3*).

Male mice of the National Institutes of Health general-purpose Swiss stock, weighing 20 to 25 g when used, were given two to three injections of antigen intraperitoneally at 5-day intervals. For the preparation of the antigens, a 20-hour culture of *Staphylococcus aureus* 18 grown in trypticase soy broth was treated in three different ways. (i) Cultures of live organisms were adjusted to give a concentration of 1×10^4 cells per milliliter. (ii) Cultures of organisms were concentrated to a level of 4×10^9 cells per milliliter and exposed to a temperature of 60°C for 1 hour on two successive days. (iii) Cultures were adjusted to deliver 4×10^9 cells per milliliter, formaldehyde was added, to a final concentration of 0.5 percent, and then the cultures were allowed to stand for 24 hours prior to use.

Each antigen preparation was inoculated into 16 mice, with each mouse receiving 0.3 ml of a mixture of equal parts of the prepared *Staphylococcus* antigen and Freund's complete adjuvant. The total amount of antigen inoculated into each mouse varied from 0.6 to 0.9 ml. Ascites appeared in 100 percent of the mice irrespective of the antigen preparation used. Repetition of this experiment yielded similar results in a separate investigation involving 60 additional mice.

In the mice receiving live antigen, ascites appeared during the third or fourth week after the primary inoculation. Formaldehyde and heat-killed antigens produced ascites in 1½ to 2 weeks, after the first injection. In each instance, the quantity of ascitic fluid obtained with an 18-gage needle varied from 2 to 12 ml per mouse. The total yield of ascitic fluid for each group of 16 mice after two to three taps at weekly intervals was 50 to 60 ml with the live organisms, 110 to 120 ml with the heat-killed antigen, and 90 to 100 ml with formaldehyde-treated culture. Freund's complete adjuvant, when mixed with uninoculated sterile trypticase soy broth, produced ascites in four of 16 mice 4 weeks after the primary inoculation.

When no further ascitic fluid could be obtained from the mice, the animals were exsanguinated. The titer of antibody in the serum was determined and compared with the titers of antibody contained in the ascitic fluid at successive taps. Antibody titers measured by the slide agglutination method were essentially the same for the ascitic fluid and the blood serum of each group of mice and varied from 1/2000 to 1/4000. There was no increase in the titer of antibodies of the ascitic fluid following booster injections given 6 to 7 weeks after the primary inoculation.

Another experiment, with a different strain, *S. aureus* 2 (*4*), showed that it, too, can induce the production of ascitic fluid containing antibodies in mice. In addition, the elimination of *Mycobacterium butyricum* in Freund's adjuvant had no effect on the number of mice affected with ascites, the volume of ascitic fluid formed, the level of antibody produced, or the duration of antibody response.

Abdominal adhesions may occur after two or three withdrawals of ascitic fluid, and difficulty in "tapping" the mouse may be encountered. These adhesions appear to be less severe if ascites is produced after two to three injections and may be dependent upon the quantity of the inoculum used and the time interval between doses.

Further studies are in progress to determine the effect of various staphylococcal components; the importance of strain, age, and sex in mice; the optimal immunization regimen; and the role of different adjuvants in the production of ascitic fluid containing antibodies in mice.

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References and Notes

1. *Staphylococcus aureus* strain 18 was recently isolated from an abscess in a patient at the National Naval Medical Center, Bethesda, Md.
2. J. Munoz, *Proc. Soc. Exptl. Biol. Med.* 95, 757 (1957).
3. E. C. Herrmann, Jr., and C. Engle, *ibid.* 98, 257 (1958).
4. *Staphylococcus aureus* strain 2 was isolated from sputum from a patient with pneumonia at the U.S. Public Health Hospital, Staten Island, New York.

16 October 1958

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper. (Since this requirement has only recently gone into effect, not all reports that are now being published as yet observe it.)

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

Phototropic Equilibrium in Phycomyces

Abstract. When illuminated by two light sources, the positively phototropic sporangiophores of *Phycomyces blakesleeanus* come into a state of phototropic equilibrium. In this state, the sporangiophores assume an orientation determined by the light fluxes falling upon opposite sides of their light-sensitive zones. Under certain conditions, the sporangiophores show tropic oscillations about the equilibrium direction.

Sporangiophores in their mature fast-growing stage were illuminated by two horizontal (*1*) light beams which made angles with each other of from 180° to 30°. When the intensities of the beams are equal, the sporangiophores assume a direction of growth that bisects the angle between the beams. Such a stable equilibrium position is often maintained for more than 12 hours, during which time the sporangiophores grow a distance of more than 3 cm. If, however, the beams

make an angle of 180° with each other, the equilibrium is indifferent rather than stable. In this case the sporangiophores continue to grow in whatever direction they were started.

When the light beams are unequal in intensity and make an angle of less than 180° with each other, the equilibrium is stable as before, but the direction of growth is now shifted toward the more intense beam. This shift in equilibrium position was measured for various relative beam intensities and various angular beam separations. The results of this work have been reported in detail elsewhere (*2*), and hence it will suffice here to summarize the findings. In all cases the direction of equilibrium is that direction for which the light-sensitive region intercepts an equal amount of flux from each beam on opposite sides of the sporangiophore.

The calculation of the amount of flux received by the sensitive zone from a single beam of parallel light is based on the following considerations: (i) The phototropically sensitive region has been estimated by Cohen and Delbrück (*3*) to extend from 0.5 to 2.0 mm below the sporangium. (ii) The sensitive zone is not always fully illuminated by an incident beam, since for certain angles of incidence the terminal sporangium casts its shadow on parts of this region. Thus, the portion of the sensitive zone that is illuminated is a simple geometrical function of the angle of incidence of the beam and of the dimensions of the sensitive zone and sporangium. (iii) The flux intercepted by the illuminated part of the sensitive zone is proportional to the intensity of the beam and to the sine of the angle between the beam and the axis of the sensitive zone. It is interesting to note that the resultant law, which applies to *Avena* coleoptiles in phototropic equilibrium (*4*), is identical to the equal flux law given above if the shading action of the sporangium is neglected.

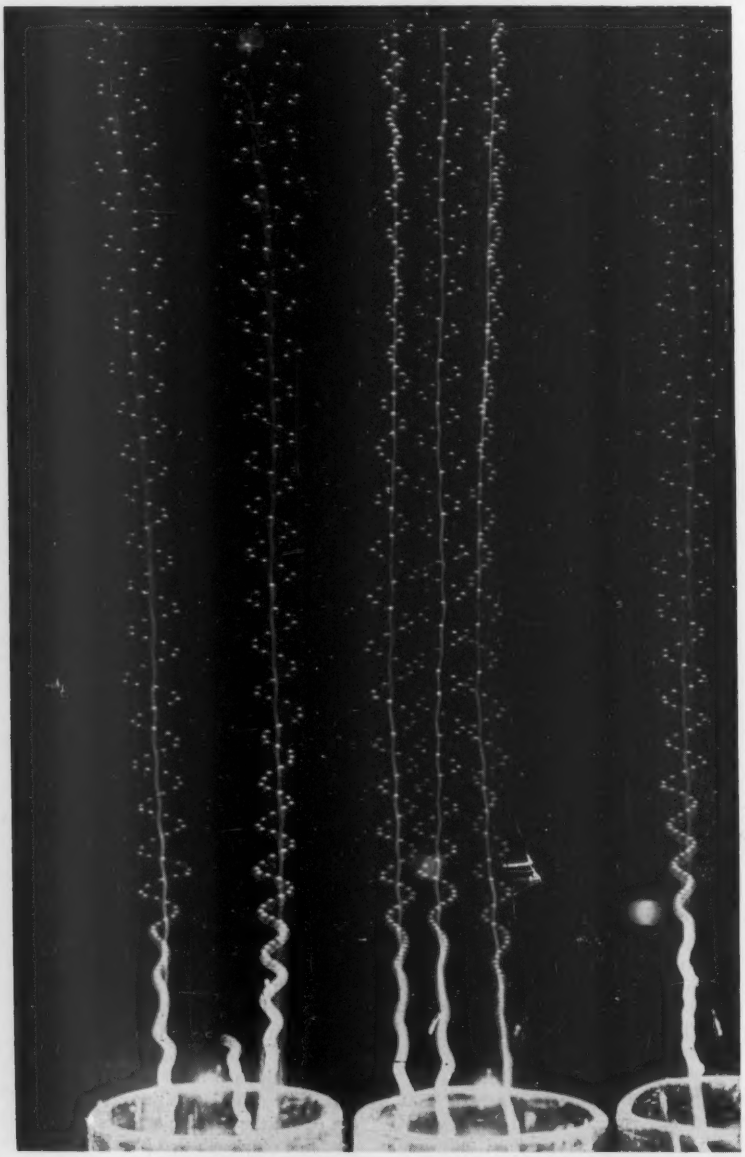

Fig. 1. Multiple-exposure photograph of a group of sporangiophores oscillating about their stable equilibrium points. The light beams were of equal intensity and were separated by an angle of 60°. Exposures were made every 5 minutes by red light, which is phototropically ineffective. The scale of the photograph is indicated by the size of the glass vials, which were 12 mm in diameter.

The most striking property of sporangiophores in stable equilibrium is the phenomenon of oscillation. Figure 1 is a time-lapse photograph of several sporangiophores in stable phototropic equilibrium. Here the sporangiophores are in a state of phototropic oscillation, in which regular rhythmic bending takes place alternately to the right and left. Each sporangium is recorded in the protograph as a wavy trail of dots as it is carried back and forth by the oscillating and growing sporangiophore.

The amplitude and period of oscillation can be obtained directly from such a photograph. The amplitude varies somewhat and has a maximum of about 30°. The period shows a remarkable regularity from specimen to specimen; at the beginning of the oscillation, when the sporangiophore is young, the period is about 60 minutes, but as the sporangiophore grows, the period drops until it reaches a value of about 30 minutes. This transition from long period to short period is quite gradual and is unaffected by changes in the amplitude. It is a somewhat curious fact that while the period of oscillation is decreasing, the rate of growth is increasing. These two processes are so synchronized that the "wavelength" of oscillation remains constant at about 2 mm.

Careful analysis of the three-dimensional path traced out by the sporangium has revealed that this path is not a flat zigzag but rather a flattened helix. The cross section of this helix is an ellipse whose major axis is about four times its minor axis. The explanation of this ellipticity of path probably lies in the fact that the growing region of the sporangiophore twists about its own axis as it grows.

A series of experiments was also carried out to determine what effect the angle between the light beams has on oscillation. It was found that oscillation

occurs if this angle is 90°, 60°, or 30° but does not occur if it is 120°, 150°, or 180°. Oscillation does not occur if a single beam is used. It was also discovered that a sporangiophore might be under conditions favorable for oscillation and yet remain in the nonoscillating state; in this case it is only necessary to give a short tropic stimulus in order to initiate the oscillation, which is then self-sustaining.

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References and Notes

1. When the beams are in the vertical plane the equilibrium is affected by negative geotropism.
2. D. S. Dennison, Ph.D. thesis, California Institute of Technology (1958).
3. R. Cohen and M. Delbrück, *J. Cellular Comp. Physiol.*, in press.
4. O. Hagem, *Bergens Museums Arbok. Naturv. Rekke* No. 3 (1911).

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17 October 1958

Flower Induction in Japanese Chrysanthemums with Gibberellic Acid

Abstract. Gibberellic acid, when applied in lanolin to apices of three Japanese varieties of *Chrysanthemum morifolium*, induced bolting and flowering. These varieties are not sensitive to photoperiod but require a cold treatment in order to flower. On the other hand, the varieties of *Chrysanthemum* which belong to the short-day group are not induced to flower by gibberellic acid.

The discovery that gibberellic acid (GA) induces bolting and flowering in several species (*1*, *2*) has stimulated much research on the flower-inducing properties of this compound. Gibberellic acid, however, seems to be unable to induce flowering in the cocklebur (*Xanthium pennsylvanicum*) (*2*) and in short-day varieties of chrysanthemum (*Chrysanthemum morifolium*) (*3*). This situation raises the following point: Is gibberellic acid ineffective, in the cited cases, because the two species, *Xanthium pennsylvanicum* and *Chrysanthemum morifolium*, happen to be nonresponsive for genetic reasons, or is it ineffective because of the physiological short-day character which these species have in common?

In order to elucidate this question, three varieties of Japanese chrysanthemums which can be induced to flower regardless of the photoperiod were selected: Shuokan, Kinkazan, and Shin-misono (*4*). These varieties require a cold treatment near 1°C for 3 to 4 weeks in order to be able to flower, whether under long-day or short-day illumination; without a cold treatment, they may remain in a rosetted condition for almost a year.

The following procedures were carried out, with eight replications per treatment for each of the three varieties: (i) controls were kept in a greenhouse at a temperature above 15°C during the whole growing period; (ii) plants were subjected to temperatures of 1° to 5°C for 4 weeks in an outdoor cold frame, then returned to the greenhouse; (iii) plants were kept in the greenhouse but were treated once, at the growing point, with about 5 mg of a lanolin paste containing 10 μg of gibberellic acid per milligram (*5*). At all times, including the periods of cold treatment, all the plants were given long, 18-hour days by supplementing the hours of natural daylight with periods of incandescent light. From each plant the lateral shoots were removed, only one main stem being left.

The results obtained were as follows. Two weeks after treatment with either gibberellic acid or cold, the stems of the respective plants started to elongate (Fig. 1). Later on, flower buds appeared, and 19 weeks after the beginning of the treatments the plants were in full bloom (Fig. 2). At that time the controls were still in a rosetted state and without any flowers. The controls eventually bolted and finally bloomed also, but much later —some 11 weeks after the treated plants had bloomed. Results were essentially similar in all three varieties, except that in the Shin-misono variety the plants treated with gibberellic acid bloomed 2 weeks later than the cold-treated ones. As is shown in Table 1, the cold-treated plants flowered at a lower node than those treated with gibberellic acid and had longer internodes.

These experiments show that gibberellic acid can induce bolting and flowering in varieties of chrysanthemum which normally require a cold treatment in order to flower. They indicate that it is not the species *Chrysanthemum morifolium*, as such, which is insensitive to the flower-promoting effect of gibberellic acid but rather the short-day characteristic of some of the varieties belonging to this species. This result strengthens the idea that gibberellic acid is not effective in inducing flowering in short-day plants (*6*).

Table 1. Effect of flower-inducing treatments on three varieties of Japanese chrysanthemums.

Variety	Controls	Gibberellic acid	Cold
Total height (cm)*			
Shuokan	17.8	95.4	85.0
Kinkazan	36.0	106.8	99.4
Shin-misono	25.2	64.0	66.6
Average length of internodes (cm)*			
Shuokan	0.31	2.27	2.64
Kinkazan	0.49	2.07	2.42
Shin-misono	0.39	1.40	2.08
*Average nodes to flower**			
Shuokan		42.0	32.2
Kinkazan		51.6	41.0
Shin-misono		45.6	32.0
Number of weeks to anthesis (from beginning of treatments)			
Shuokan	30	19	19
Kinkazan	29	20	19
Shin-misono	31	22	20

* Nineteen weeks after the beginning of treatments.

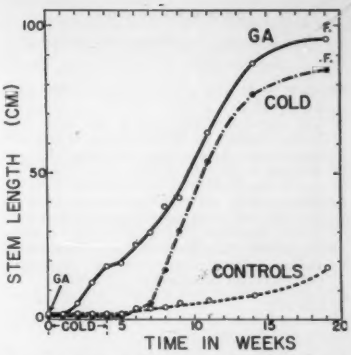

Fig. 1. Growth curves of Japanese chrysanthemums, var. Shuokan, subjected to the following treatments: (open circles and solid line) about 50 μg of gibberellic acid applied in a lanolin paste to the growing points at time 0; (solid circles) 4 weeks of cold treatment; (open circles and dashed line) controls. (Each point represents the average of eight replications.)

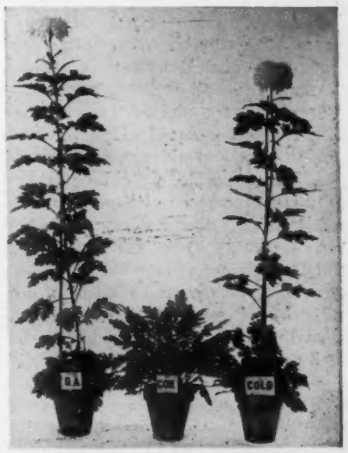

Fig. 2. Induction of bolting and flowering in Japanese chrysanthemums, var. Shuokan, 19 weeks after the application of gibberellic acid (left) or the beginning of a 4-week cold treatment (right). The control (middle) remained rosetted and vegetative.

These results indicate that it is not the species *Chrysanthemum morifolium*, as such, which is insensitive to the flower-promoting effect of gibberellic acid but rather the short-day characteristic of some of the varieties belonging to this species. This result strengthens the idea that gibberellic acid is not effective in inducing flowering in short-day plants (*6*).

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Bromination of Phenol Red by the Dogfish, Squalus acanthias

Abstract. The uterus of the pregnant spiny dogfish, *Squalus acanthias,* can convert phenol red into a new purplish-blue dye. Evidence shows that the new dye is bromophenol blue. This is the first example of biological bromination that has been observed in a vertebrate.

Apart from thyroxin and related substances, naturally occurring halogenated organic compounds are rare in animals. Certain species of shellfish, particularly *Murex brandaris* and *M. trunculus,* secrete a colorless liquid which, on exposure to light and air, gives the ancient dye, Tyrian purple, 6,6′-dibromoindigo (*1*). The occurrence of another bromocompound, 3,5-dibromotyrosine, has also been reported (*2*) in the skeletons of certain anthozoans. However, there appears to be no recorded instance of bromine being incorporated into an experimentally introduced exogenous material. The data presented in this report (*3*) indicate that the uterus of the pregnant spiny dogfish, *Squalus acanthias,* an elasmobranch, can convert the dye phenol red (phenolsulfonphthalein) into bromophenol blue (3,3′,5,5′-tetrabromophenolsulfonphthalein) (*4*).

The spiny dogfish has a gestation period of almost 2 years. In the first summer of pregnancy, the eggs in each uterus are enclosed in a common capsule, with the uterine wall in close apposition to the capsule. The capsule is broken, and in the second summer the embryos—small fish with yolk sacs, now called pups—lie free in the uterine cavity. The uterine fluid from the capsule stage (usually a few milliliters) has an electrolyte and urea content resembling that of elasmobranch blood. The uterine fluid of the pup stage, normally 50 to 100 ml, has no urea and has the same electrolyte composition as sea water, but with a *p*H of 5 to 6 (occasionally somewhat higher). The uterocloacal pore becomes flaccid, so that one can easily insert one's finger, and some uterine fluid is frequently lost when the fish is handled. Spontaneous intermittent emptying and filling of the uterus overnight was observed experimentally; this suggested that the sea water may gain direct entrance into the uterus. Whether the bromine used in the conversion of the phenol red comes from this uterine water or comes directly from the dogfish awaits further investigation.

In connection with a study on uterine function in the dogfish, phenol red, shown by paper chromatography to be free from any contaminating dyes, was dissolved in sea water, and 50- to 100-ml portions were introduced by funnel into the uteri of dogfish in the second summer of pregnancy. Saturated solutions as well as various dilutions of the dye were used. After 24 to 48 hours, all or most of the phenol red was replaced by a purplish blue dye, later identified as bromophenol blue. The conversion occurred without exception in each of the eight fish tested. Throughout the experiment, the dogfish were kept alive in sea water at 14° to 15°C.

Although the new dye (*X*) obtained from the uterine fluid (*p*H about 5 to 6) after the phenol red treatment is purplish blue in color, it soon turned yellow upon acidification. Further, the color change covered a *p*H range from 3.5 to 4.5, in agreement with that reported for bromophenol blue (*5*). The structural relationship between the two dyes suggests that this new dye may in fact be bromophenol blue or may be closely related to it. Chromatographic and light-absorption evidence supports the first possibility.

The uterine fluid containing the blue dye was acidified to about *p*H 1 with dilute HCl and extracted three times with benzene; each time about one half the volume of the aqueous phase was used. The benzene extract was washed with an equal volume of water and was then allowed to evaporate almost to dryness. The orange residue was finally recrystallized from methanol. Unfortunately the minute quantity of pure material did not permit a satisfactory ultimate analysis (*6*). Microfusion with sodium followed by micro- qualitative analysis did, however, result in a positive test for bromine and a negative test for iodine (*7*).

Chromatographic behavior in four solvent systems failed to show any significant difference between the blue dye *X* and bromophenol blue (Table 1). Additional faint spots of fluorescence were seen in two of the systems employed, as is indicated in the same table.

The light-absorption characteristics of the two dyes, in acidic and alkaline media, respectively, are listed in Table 2. The spectra of *X* and bromophenol blue were exactly superposable in the visible region, from 400 to 600 mμ. Between 220 and 360 mμ, the dye *X* demonstrated slightly stronger light absorption than bromophenol blue, but the maximal absorption of both occurred at exactly the same wavelength. In any event, the evidence at hand strongly suggests that the dye *X* and bromophenol blue are really one and the same.

No perceptible bromination of phenol red was observed under the following conditions: incubation of living or dead embryos with phenol red in sea water for 30 hours and incubation of phenol red with uterine fluid, blood plasma, and urine, respectively, for 72 hours at room temperature and also in the refrigerator at about 4°C. Uteri with embryos killed by asphyxia resulting from withdrawal of

Table 1. Comparison of the chromatographic behavior of the dye *X* and of authentic bromophenol blue (BPB). (Whatman No. 1 paper, ascending flow.) The spots indicated in the table appeared red under ultraviolet light in the 366-mμ region.

Compound	R_f			
	3% NaCl	BuOH-HOAc-H_2O (4:1:1)	BuOH-EtOH-H_2O (4:1:5)	BuOH saturated with 1.5*N* NH_4OH
X	0.65	0.76*	0.41†	0.41
BPB	0.61	0.76	0.44	0.42

* An additional faint spot of yellow fluorescence with R_f value 0.64 was also visible.
† An additional faint spot of yellow fluorescence with R_f value 0.61 was also visible.

Table 2. Optical densities (OD) of the dye *X* and bromophenol blue at their respective wavelengths of maximal absorption. The spectra were all determined in methanol. The concentration of bromophenol blue (BPB) was 10 μg/ml.

Compound	*p*H	λ_{max_1} (mμ)	OD	λ_{max_2} (mμ)	OD	λ_{max_3} (mμ)	OD
X	1.6	278	0.26	421	0.33		
BPB	1.6	278	0.17	421	0.33		
X	10.7	314	0.28	380	0.10	594	1.16
BPB	10.7	314	0.24	380	0.10	594	1.16

all uterine fluid 24 hours before infusion with phenol red did, however, effect bromination.

Further studies are in progress to determine the site and mechanism of the bromination. Perhaps there exists, in certain marine animals, an enzyme system which catalyzes the bromination described above. The biological halogenation of phenols may be analogous to the biogenesis of thyroxin where tyrosine residues undergo iodination (*8*).

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6. A small amount (1.6 mg) of the crystalline material was nevertheless submitted for analysis for bromine; 37.06 percent was found. This seems to fit for bromophenol blue decahydrate; bromium content calculated for $C_{19}H_{10}Br_4O_5S \cdot 10\ H_2O$, is 37.60 percent. The microanalysis was performed by William C. Alford of the National Institute of Arthritis and Metabolic Diseases.
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6 October 1958

Ion Adsorption and Excitation

Abstract. A simple calculation shows that the K ions about to leave the nerve during excitation form a monolayer at the surface of the resting nerve and are not hydrated. The same applies to the Na ions which replace the K ions. This may be taken as an indication of the existence of a reversible ad- and desorption phenomenon.

An important ionic relationship associated with the excitation process becomes apparent in the following way. Let it be assumed that there is a specific volume V_K of the nerve substance in which the original concentration K_1 of potassium ions changes to that of the bathing fluid K_o as a result of the net K ion loss incurred during a single discharge. This takes the form

$$V_K = K_{flux}/(K_i - K_o)$$

Knowing V_K and taking the flux quantity as distributed uniformly over the area of 1 cm², one can arrive at the thickness d_K of the nerve layer immediately involved in the exchange of K ions.

This simplified system is considered to be a valid one because of the steplike character of the K ion concentration gradient existing in the resting state between the two phases (that is, axoplasm and bathing solution). An additional advantage is the fact that the thickness thus obtained corresponds to that of a monoionic layer, obviating the necessity of considering a possible diffusion process which would tend to restore the internal K ion concentration to a uniform level. Similar reasoning holds with regard to d_{Na}.

The actual calculations were performed on the basis of the net ion flux data (K = 4.3 pmole/cm² per impulse, Na = 3.7 pmole/cm² per impulse) given by Keynes (*1*). The inner and outer ion concentrations used are those given by Keynes (*1*) for the *Sepia* axon (Na_i = 110 mmole/kg, Na_o = 458 mmole/kg, K_i = 272 mmole/kg, K_o = 9.7 mmole/kg), and those given by Hodgkin (*2*) for the *Loligo* axon (Na_i = 49 mmole/kg, Na_o = 440 mmole/kg, K_i = 410 mmole/kg, K_o = 22 mmole/kg).

The results are as follows, the figures in parentheses being values obtained from the second set of data.

$$d_K = 1.6393\ A\ (1.109\ A)$$
$$d_{Na} = 1.063\ A\ (0.946\ A)$$
$$d_K/d_{Na} = 1.54\ (1.172)$$

Examination of these results shows that the thickness of the nerve layer involved in ionic fluxes lies in the range of the effective radii of the ions considered (K = 1.33 A; Na = 0.98 A). In addition, the average of the two d_K/d_{Na} ratios obtained equals 1.367, which is very close to 1.357, the ratio of the effective radii of the K and Na ions.

It is thought that these results may justify the conclusion that the nerve layer immediately involved in ionic shifts allows for the presence of only one-half of a monolayer of nonhydrated cations. Accordingly, the original formulation is modified to take the form

$$f = A\ r\ (C_i - C_o)$$

where f is the net flux in moles per impulse, the sign denoting its direction; A is the area of the nerve in square centimeters; r is the effective radius of the ion in centimeters; and C_i and C_o are the inner and outer ion concentrations in moles per cubic centimeter.

Conversion of the concentrations into osmotic pressures shows the flux to be inversely proportional to the absolute temperature, a relation which is in line with the experimental evidence presented by Shanes (*3*).

Taking Hodgkin's data for plasma concentrations (*2*) and the flux values as above, one obtains from the flux formula K_i = 345.3 mmole/kg and Na_i = 62.45 mmole/kg. These values agree with those given by Koechlin (*4*) for the squid giant axons (K_i = 344 ± 15 mmole/kg, Na_i = 65 ± 15 mmole/kg), thus indicating a possible confirmation of the validity of the derived expression.

The emergence of the effective ionic radii implies that electrostatic forces may be at work and that the excitation phenomenon may involve to a greater or lesser degree an adsorption phenomenon (*5*).

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14 August 1958

Proliferation of Excised Juice Vesicles of Lemon in vitro

Abstract. Juice vesicles from mature lemon fruits will proliferate *in vitro* for indefinite periods. The comparatively simple tissue grows on a synthetic nutrient medium almost entirely inorganic in composition.

Many types of excised meristematic plant tissues or parts have been the subject of in vitro studies, but the successful culture of tissue from a mature fruit is mentioned only briefly in the literature. The first in vitro studies of fruit tissues were started by Schroeder (*1*) and are under way at present on several different fruit species (*2*).

In the present study mature lemon fruits (variety Eureka) were surface-sterilized by immersion for 20 minutes in a saturated calcium hypochlorite solution, rinsed with sterile water, and cut longitudinally into eighths. Removal of

Fig. 1. (Left) Vesicle stalk after 65 weeks of in vitro growth. (Right) Dead vesicle stalk after 6 weeks of in vitro growth.

the locular membrane permitted entire vesicles (sac plus stalk) to be individually obtained by plucking the stalk at the base with a sharp pointed forceps. The vesicles thus removed were soaked in a buffer solution (0.10*M* phosphate, *p*H 7.0) for 15 minutes and placed on liquid nutrient media in screw-cap vials. The tissues were supported by reagent grade sea sand (Merck) or Du Pont cellulose sponge (yellow color) topped with Whatman No. 42 ashless filter paper discs.

The nutrient medium was entirely inorganic in composition except for sucrose as a carbon source (Table 1) and a small quantity of organic material supplied as ferric citrate or iron chelate-138 (Geigy Chemical Corp.). The medium was buffered by phosphate salts ($K_2HPO_4 + KH_2PO_4$) which also served as the sole phosphate source. The buffer system used was that of Colowick and Kaplan (*3*).

The vesicles started proliferating approximately 2 to 3 weeks after they were planted (May 1957) and are still producing new cells (13 January, 1959) (Fig. 1, left). Subcultures also carry on mitotic activity for long periods (10 months) and have gained in fresh weight as much as 2600 percent. The vesicle stalk appears to be the primary seat of growth activity. This tissue is capable of proliferating when it is attached to or removed from the juice sac. Occasionally the juice sac will proliferate, but only when the stalk is attached. Growth is most vigorous in the *p*H range 7.0 to 7.7 and occurs to a lesser extent at *p*H 6.0. The growth is visibly the same at all the above *p*H levels. None occurs at *p*H levels below 6.0 under the conditions employed.

Nutrient media which had supported the growth of the excised tissue for 81 days yielded entirely negative results when they were tested for aerobic and anaerobic microorganisms. The results suggest that mature lemon juice vesicles possess the inherent capacity to carry on cell proliferation for indefinite periods under relatively simple *in vitro* conditions.

Table 1. Composition of nutrient solution. Phosphate (0.01*M* total) was supplied by the buffer salts.

Compound	Amt. (g/lit.)	Ion or element (ppm)
$CaCl_2 \cdot 2H_2O$	0.1470	Ca^{++}, 40.0 Cl^-, 71.0
KNO_3	0.5090	K^+, 200.0 NO_3^-, 312.0
$MgSO_4 \cdot 7H_2O$	0.1080	Mg^{++}, 10.0 SO_4^{--}, 42.3
$MnSO_4 \cdot 4H_2O$	0.0050	Mn^{++}, 1.25 SO_4^{--}, 2.16
$ZnSO_4 \cdot 7H_2O$	0.0022	Zn^{++}, 0.50 SO_4^{--}, 0.738
$(NH_4)_6Mo_7O_{24} \cdot 4H_2O$	0.0037	Mo, 2.0 NH_4^+, 0.0003
H_3BO_3	0.0028	B, 0.50
Fe-138*	0.0467	Fe^{+++}, 5.0 chelate, 41.0
Fe-Citrate†	0.0273	Fe^{+++}, 5.0 citrate, 16.86
$CuSO_4 \cdot 5H_2O$	0.0012	Cu^{++}, 0.30 SO_4^{--}, 4.50
Sucrose	34.250	

* Chelate-138 was used in all nutrient solutions buffered above *p*H 6.0.
† Ferric citrate was used in all nutrient solutions buffered at *p*H 6.0 and lower.

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18 August 1958

Requirements for Floral Initiation of Los Angeles Xanthium

Abstract. Cocklebur from the Los Angeles area was found to require more extensive short-day treatment for floral initiation than plants of the same species from the Chicago region. Data obtained by grafting the two regional types of cocklebur indicate that the leaves of the Los Angeles *Xanthium* produce a comparatively low amount of the flowering stimulus.

The cocklebur, *Xanthium strumarium* L. var. *canadense* (Mill.) T. and G. (*1*), which has been most commonly referred to in the past as *Xanthium pennsylvanicum* Wallr., is generally recognized as the most sensitive short-day plant now known. Although it can be maintained indefinitely in the vegetative state under long-day conditions, a single dark period of 8¾ hours or more will initiate floral development (*2*). The acknowledged esthetic deficiencies of the plant are more than compensated for by its usefulness as a test organism for assessing the effectiveness of a given treatment in terms of the short-day flowering response.

Most investigations employing *Xanthium* have used plant material derived from the fruit of wild plants collected in the vicinity of Chicago, Ill. The species range, however, extends in a wide belt from Florida through California, and from Quebec through North Dakota (*3*). Although it is taxonomically identical to the Chicago stock, *X. strumarium* from the Los Angeles area has been recognized (*4*) as being generally less sensitive to dark treatment than its Chicago counterpart.

The experiments described in this report constitute an evaluation of the critical day length for the Los Angeles *Xanthium* and, in addition, represent an attempt to determine a basis for the difference in response between the Los Angeles and the Chicago types.

Burs from wild Los Angeles stock were soaked in water for 12 hours before they were planted in flats of soil. Two weeks after emergence, 15 seedlings from each flat were selected for uniformity; all other plants were removed. All plants were maintained in cold frames throughout their growth period. Before and after the actual interval of photoinductive treatment the plants were maintained under continuous illumination, the natural day length being supplemented at night with incandescent light of intensity approximately 50 ft-ca at the leaf surface.

Two weeks after the last dark treatment the terminal buds were examined under a low-powered dissecting microscope and assessed with respect to the relative stage of floral development that had been attained. Results were evaluated in accordance with a numerical scale based on the diameter and morphological stage of development of the terminal staminate inflorescence. Vegetative plants were rated as zero on the scale. The first morphological change in the stem apex that could be clearly recognized as flowering was assigned a value of 1.0. A flowering apex measuring 0.25 mm in diameter was evaluated as 2.0. An additional increment of 1.0 was allowed for each 0.25-mm increase in the diameter of the developing inflorescence (*5*).

The treatments employed in the determination of the critical day length are listed in Table 1. From these data it is apparent that no flowering occurs in Los Angeles plants subjected to dark periods of 11 hours' duration or less. A single dark treatment of 20 hours was ineffective. The critical day length of the Los Angeles stock is, therefore, between 11 and 12 hours of darkness, and more than one photoinductive treatment is required for minimal floral initiation. Three photoinductive cycles with dark periods of 12-hour duration resulted in a low flowering response. An increase in

Table 1. Effect of dark treatment on the flowering response of Los Angeles *Xanthium*.

Darkness (hr)	Av. flowering response, with short-day treatments				
	No. of treatments				
	1	3	5	5*	Continuous treatment
9		0.0	0.0	0.0	0.0
10			0.0	0.0	0.0
11		0.0	0.0	0.0	0.0
12		0.2	1.9	0.7	10.9
13		0.9	4.0	2.9	
16	0.0	3.2			
20	0.0				

* Noninductive day length alternated with short-day treatment.

Table 2. A comparison of relative responsiveness to photoperiodic treatments of leaf and bud combinations from Los Angeles and Chicago *Xanthium*.

Treatment	Av. flowering response
A. Chicago bud grafted to Los Angeles leaf	0.0
B. Los Angeles bud grafted to Chicago leaf	2.0
C. Los Angeles bud grafted to Los Angeles leaf	0.0
D. Chicago bud grafted to Chicago leaf	4.4
E. Los Angeles bud defoliated	0.0
F. Chicago bud defoliated	0.0
G. Chicago plant (not grafted)	13.4
H. Los Angeles plant (not grafted)	2.8

either the length or the frequency of the dark period resulted in a corresponding increase in floral development. It is of interest to note that alternation of noninductive day length and short-day treatment (Table 1) effectively lowered the flowering response. This is in accord with the results of Lincoln *et al.* (*6*).

In explanation of the low level of flowering response of the Los Angeles *Xanthium*, as compared with the floral development that would be expected in the Chicago stock under comparable conditions of illumination, two possibilities were considered: (i) The buds of the Los Angeles plants may require a greater amount of stimulus to initiate flowering, and (ii) the leaves of the Los Angeles plants may produce less stimulus than the leaves of the Chicago type produce under comparable photoinductive conditions.

The following experiment was designed to test the validity of these postulates. The plants were germinated in flats and 1 week after emergence were transplanted singly to 4-in. pots. The individual plants of the Los Angeles and Chicago types were trimmed and debudded, a single leaf being retained on the donor plant and a single terminal bud on the receptor plant. The plants were grafted 4 weeks after transplanting, and the first short-day illumination was provided 3 days after grafting. All other conditions were the same as those described above.

The data listed in Table 2 indicate that five inductive cycles involving dark periods of 16 hours' duration do not initiate flowering in either a Chicago or a Los Angeles bud in association with a Los Angeles leaf. A Chicago leaf, however, under the same photoinductive treatment will cause floral initiation in either bud type. The intact control plants of both the Chicago (treatment G) and the Los Angeles (treatment H) types flowered in response to the photoinductive treatment. As would be expected from the data given in Table 1, the Los Angeles plants were less responsive to short-day treatment than the Chicago plants. The graft apparently restricted to some extent the amount of stimulus moving from the leaf to the scion bud. It is apparent that the low response of the Los Angeles plants can be attributed in some measure to the small amount of stimulus supplied by the leaf. The response of the Los Angeles bud to a Chicago leaf was less than that of the Chicago bud to a leaf of the same type. The Los Angeles bud therefore may have a somewhat higher requirement for comparable floral initiation.

Variations in natural day-length conditions may exert a selective influence on the photoperiodic responses of a plant. A single plant species distributed over a wide longitudinal range may exhibit differences in photoperiodic sensitivity corresponding to the gradation in longitudinal distribution (*7*). The observed difference in the response of Los Angeles *Xanthium* to photoperiodic induction may represent a similar pattern of natural selection.

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29 September 1958

Hetero Blood Types and Breeding Performance

Abstract. The phenomenon of hybrid vigor apparently depends to some extent upon the degree of diversity between the genes of the two parents. Results are presented which suggest that diversity of cellular antigens might be used as an indicator of general genetic diversity between mates.

In livestock breeding, the phenomenon of hybrid vigor is often manifested by vigorous offspring with a relatively high rate of survival. Generally, the more different the parents are genetically, the more pronounced is the phenomenon of hybrid vigor (*1*). The absence of means to measure the genetic diversity between animals to be used in a breeding program aimed at utilizing hybrid vigor is a deterrent to a widespread exploitation of this phenomenon. The cellular blood antigens of cattle are controlled by genes located on at least 11 different chromosomes, and it has been demonstrated that the frequencies of the blood types vary between different breeds and strains (*2*). A study was made of breeding results in dairy cattle in which the cellular antigens of the mates were known.

Table 1. Data on matings between 310 females and 32 males of the Holstein-Friesian breed.

No. of antigens in which mates differed	No. of matings	No. of offspring	No. of offspring that survived (%)
1– 5	305	140	46
6– 7	433	212	49
8– 9	357	176	49
10–15	169	101	60
Total	1264	629	50

In order to study whether similarity or dissimilarity of mates influences the probability of survival of the young, a tabulation was made of 1264 matings between 310 females and 32 males of the Holstein-Friesian breed, in which the presence or absence of 20 different cellular antigens had been determined (*3*). Only matings between supposedly fertile animals were included in the tabulation shown here.

The matings were classified on the basis of the number of cellular antigens in which the two mates differed. The results are presented in Table 1.

The rate of survival increased as the difference in antigens increased. The chi-square of 8.72 is significant at the 0.05 level.

No claims are made that cellular antigens are responsible for fertility and successful embryonic development. However, dissimilarity of antigens may be used as an indicator not only of dissimilarity of genes affecting blood antigens but of dissimilarity of other genes affecting productive traits as well. Further studies on other productive traits seem justified in order to determine whether differences manifested with respect to blood antigens might be used as a guide in mating for "hybrid vigor" (*4*).

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3 October 1958

Use of an Organic Carbon Dioxide Buffer in vivo

Abstract. The compound 2-amino-2(hydroxymethyl)1,3-propane diol was administered intravenously to apneically oxygenated dogs over a 1-hour period. Arterial blood pH remained normal, and an estimated 18 to 28 percent of the CO_2 produced during apnea was recovered in the urine.

Pardee (*1*) and Krebs (*2*) have shown that in vitro "CO_2 organic buffers" can maintain pCO_2 constant in the gas phase according to the equation:

$$R\text{-}NH + H_2O + CO_2 \rightleftharpoons HCO_3^- + R\overset{+}{N}H_2$$

One of these compounds, $(CH_2OH)_3C\text{—}NH_2$, was utilized in the apneically oxygenated dog to combat the increase in pCO_2 and the concomitant rise in H^+ concentration.

"Apneic oxygenation" (*3*) is a condition of ventilatory arrest, induced with succinylcholine chloride, following a 1-hour period of ventilation with 100-percent oxygen (denitrogenation), and during which the trachea is connected to a reservoir containing 100-percent oxygen. In this condition oxygenation of the blood is maintained but CO_2 accumulates. After 1 hour of apnea one typically observes (*4*): (i) a 50-percent fall in arterial oxygen saturation and a fall in oxygen uptake to 60 percent of the control value; (ii) a rise in arterial pCO_2, (for example, to 376 mm-Hg), in total plasma CO_2 (to 41.4 mmole/lit.), and in plasma HCO_3 (to 31.0 mmole/lit.); (iii) a fall in arterial blood pH (for example, to 6.56) and a drop of the plasma HCO_3^-/H_2CO_3 ratio to 3. Signs of severe hypercapnia are present: wide fluctuations in systemic blood pressure, bradycardia, cardiac arrhythmia, a 200-percent increase in intracranial pressure, a rise in serum potassium level, and anuria. It has been established (*4*) that 40 percent of all dogs maintained under such conditions die within the hour of apnea. Reestablishment of spontaneous ventilation in the survivors required at least 1 hour of mechanical ventilation with pure oxygen.

Six mongrel female dogs were subjected to "apneic oxygenation" for periods of 1 hour to 1 hour and 20 minutes. At the onset of apnea an intravenous 0.33*M* infusion of 2-amino-2(hydroxymethyl)1,3-propane diol (*5*) in 0.2-percent NaCl was administered at the rate of 1 ml/kg min—a quantity deemed sufficient to bind the estimated amount of CO_2 produced by the animal (approximately 0.33 mmole/kg min). After 1 hour of apnea, (i) arterial oxygen saturation was 100 percent and oxygen uptake was at preapneic levels; (ii) average arterial pCO_2 was 89 mm-Hg, total plasma CO_2 was 52.9 mmole/lit., and plasma bicarbonate was 50.1 mmole/lit.; (iii) arterial blood pH was maintained within 0.2 pH unit of the control preapneic level and after 1 hour of apnea averaged 7.37; the HCO_3^-/H_2CO_3 ratio was 19. Mean blood pressure remained close to that of the preapneic control period and heart rate decreased, but no arrhythmia occurred, and cerebrospinal fluid pressure did not change significantly from normal (Fig. 1). Serum potassium levels remained constant, and instead of renal shutdown there was profuse diuresis.

The urinary pH averaged 7.54, the HCO_3^- concentration was 89 mmole/lit., and 26 percent of the estimated total CO_2 produced by the animal during apnea (*6*) was recovered in the urine. The dogs resumed spontaneous breathing between 15 and 20 minutes after the end of the procedure, and all of them survived, without any apparent ill effect. Two animals in this series underwent successfully a second period of 80 minutes of apnea, 16 and 23 days, respectively, after the first one.

This organic buffer base appears to combat the deleterious effects of CO_2 retention in two ways. The compound's CO_2 buffering capacity maintained pH within the normal range and limited the rise in pCO_2, even though the total amount of CO_2 produced and retained by the body was considerably greater than it was in the control group of apneically oxygenated animals. (The lesser production of CO_2 by the control animals, as compared with that of the experimental group, probably reflects a depression of metabolic function.) In addition, 18 to 28 percent of the estimated total amount of CO_2 produced during apnea was excreted by way of the kidney.

Although the amount of CO_2 retained within the organism is high, it would appear that the living organism can tolerate it well when its two fractions, bicarbonate and free carbonic acid, are in suitable proportion to maintain the acid-base balance of the blood within normal limits.

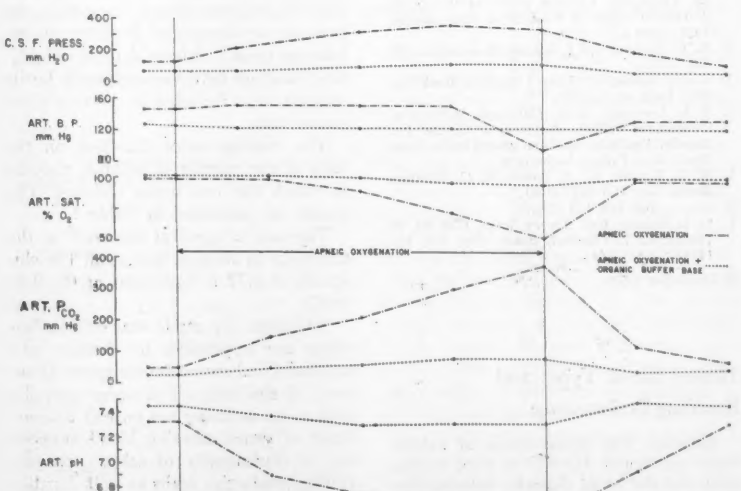

Fig. 1. Effects of intravenous administration of organic buffer base $[(HOCH_2)_3\text{—}C\text{—}NH_2]$ in a dog during a 1-hour period of "apneic oxygenation." While extreme changes are observed during a similar period of apnea in a control animal (dot-dashed line), in the test animal (broken line) there is little or no change in cerebrospinal fluid pressure (CSF), in percentage of oxygen saturation of arterial blood, or in arterial blood pH, and there is a 45 mm-Hg rise in arterial pCO_2.

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5. This compound is commonly known as "tris-hydroxymethylaminomethane" or "tris buffer."
6. The CO_2 produced was calculated on the basis of oxygen uptake when $R = 0.8$.

26 September 1958

Synchronization of Unit Activity in the Cerebral Cortex

Abstract. Simultaneous recording with micropipette electrodes from different units in the cerebral cortex revealed that units seldom fired synchronously. However, there was a temporal relationship in unit firing even when the cortex was "aroused." This relationship was most apparent when strychnine and stimulation were applied to a sensory nerve of an animal asleep or under deep anesthesia.

In a discussion on the electrical activity of the cerebral cortex, Adrian (*1*) stated that "groups of nerve cells very often tend to act in unison when there is nothing to prevent them." Random afferent messages received at the cortex resulted in a breaking down of the synchronous activity of the nerve cells. If the afferent messages were simultaneously received, or if strychnine or some other chemical agent was applied, groups of nerve cells would again respond in unison. This notion was derived from, and subsequently supported by, observations on the waves of potential recorded from isolated structures or fragments of nervous tissue (*2*) and from the cortex of experimental subjects (*3, 4*).

Recently, microelectrodes were used to record unit spike discharges which presumably originated from single nerve cells. Under certain conditions the waves of potential occurred independently of the unit spike discharges (*5, 6*), indicating that they do not necessarily represent envelopes of spikes (*5*). Although observations from these experiments with microelectrodes sometimes suggest the presence of synchronization of unit discharges, especially subsequent to the application of strychnine (*7*), the activity of different cortical units was not simultaneously investigated.

This report concerns the activity of cortical neurons simultaneously recorded with two micropipette electrodes inserted into the somatosensory cortex of cats. The tips of the microelectrodes were estimated to be less than 0.5 mm apart. When a microelectrode picked up spike activity, it was left undisturbed while the other microelectrode was used to study similar activity of other nerve cells within a sphere approximately 1 mm in diameter. Cats were prepared either with a transection between the superior and inferior colliculi (*4*) or with intraperitoneal injection of thiopentone sodium. Stimulating electrodes were placed on a peripheral sensory nerve contralateral to the exposed somatosensory cortex. Toward the end of each experiment, strychnine solution was applied to the area of the cortex where the electrodes were inserted.

The "spontaneous" discharges of the cortical units recorded from Bremer cats and from cats under deep general anesthesia were remarkably similar. They occurred in bursts, each consisting of five to ten short trains of spikes; the intervals between the trains measured from 100 to 400 msec (Fig. 1, *A*). The spike trains recorded from any given pair of units appeared almost simultaneously, with discrepancies varying from 2 to 40 msec. Recordings from cats under light general anesthesia showed many units discharging also in bursts, but the temporal relationship between the bursts from different units was less clear. At times, rythmic bursting activity was recorded from one unit while random discharges were obtained from the other unit. While the animal was waking, bursting activity became less frequent, and when the tail of the cat was pinched, continuous discharges of spikes were recorded. However, a close examination of the records, such as that shown in Fig. 1, *B*, revealed that although synchronous discharges of the two units were scarcely present, there was a tendency for the discharges of the units to pause at about the same time and for the periods to be of similar length (as indicated by the dots in the record).

Stimulation of the peripheral nerve elicited responses with initial spike latencies at intervals either between 5 and 10 msec or between 20 and 30 msec (Fig. 1, *C* and *D*). Those occurred at intervals of 5 to 10 msec and sometimes recurred at intervals of 20 to 30 msec (Fig. 1, *E*). Application of strychnine caused, in most instances (52/60), repetitive discharges in nearly synchronous trains, with discrepancies of 1 to 8 msec in the initiation of the first spike discharge in the trains (Fig. 1, *F*). On some occasions (8/60) the repetitive discharges of one unit were not accompanied by repetitive discharges of the other (Fig. 1, *G*).

The observations cited above, therefore, provide direct evidence to support the notion originally proposed by Adrian (*1*). There are, however, some limiting considerations. (i) Units within a sphere of 1-mm diameter seldom fire at precisely the same instant. (ii) When the cortex is "aroused," the unit activity is said to be "desynchronized," but a relationship between the discharges of the units still exists. (iii) Evoked spike re-

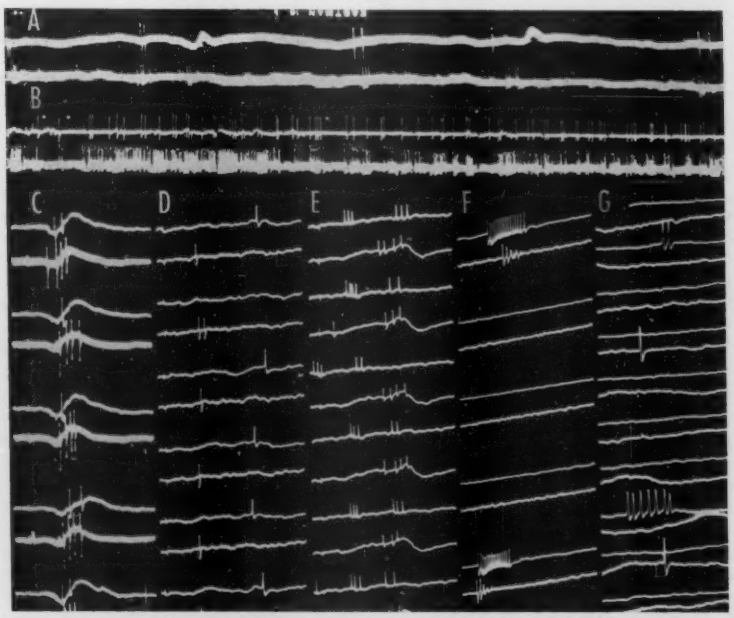

Fig. 1. Synchronous discharges of nerve cells in cerebral cortex: *A*, Discharges subsequent to Bremer section between superior and inferior colliculi; *B*, discharges in response to tail-pinching when cat was waking up from general anesthesia; *C, D, E*, responses to peripheral sensory nerve stimulation; *F, G*, trains of spike discharges following local application of strychnine. Upward deflection represents positivity. Horizontal bars represent 200 msec in *A* and *B*, 5 msec in *C* through *G*. Vertical bars represent 2 mv.

sponses of a given unit to sensory volleys scarcely vary in their latencies, but responses of some units occur about 20 msec following the responses of other units or recur about 20 msec after their initial responses. (iv) Application of strychnine causes repetitive discharge in nearly synchronous trains of approximately 85 percent of, but not all, the cells.

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15 October 1958

Reliability of Activation Level during Adaptation to Stress

Abstract. This study points out the stability of a quotient expressing the recovery of basal skin resistance (BSR) level. Changes noted in BSR during stress are consistent with the behavior of tranquilized patients and have significance for drug therapy. Information of this type may be quite useful for interpretation and objectivity in a wide range of clinical researches.

To date, studies of the reliability of BSR measures have concentrated on work with normal subjects and tend simply to demonstrate adaptation after repeated exposure to the stimulus. The following study was primarily designed to appraise the reliability of the base-line adaptation of mental patients during stress. Basal skin resistance was the measure chosen since it is inversely related to sympathetic nervous activity or "activation level."

The subjects comprised two groups of 16 patients each, one group composed of 13 on various tranquilizers of the phenothiazine class plus three on Marsilid, an "energizer," and the other group consisting of nondrugged patients. Silver electrodes, stabilized by reversal of polarity every 3.1 sec, were applied to the palms of the patient's hands. The patient reclined on a couch and was instructed to look continuously at a Strobolux which was used to deliver a large field of flickering light from a distance of 7 ft. The Strobolux was turned on after a relaxation period of 10 min. Readings of BSR separated by ½-min intervals were made during the following periods: (i) 0.5 to 1.5 min, the initial resting period; (ii) 9 to 11.5 min; and (iii) 16 to 17 min. After a 3-day interval the procedure was repeated on each patient.

Two test-retest reliabilities were computed by using the following scores which were selected in advance of the data: (i) increase in BSR over the 7-min exposure to flicker, divided by the initial decrease in BSR due to flicker stimulation; (ii) increase in BSR, as above, divided by BSR just after Strobolux stimulation—that is, at 10.5 min.

Although the first of these scores is highly recommended in the literature for measuring the recovery quotient, its use gave insignificant reliabilities. The data strongly suggest that this is due to anticipatory activation during the second session. The use of the second score gave rank order correlations of .72 ($p < .01$) for both drugged and nondrugged groups and a total product moment coefficient of .78 ($p < .01$) for the combined groups. Considering that the second score compounds unreliabilities resulting from changes in adaptation and changes in BSR level at 10.5 min, the reliability is surprisingly high over a 3-day period when the anticipatory effects are taken into account.

A subsidiary experiment, an exploratory attempt at evaluating the validity of BSR measures of activation level, was conducted with data obtained from the above study. Casual clinical observations made by me and my associates on patients under the influence of tranquilizing drugs yielded general agreement to the effect that these patients were manifestly less aroused than those who were not receiving tranquilizing drugs. It was then reasoned that the manifest validity of BSR should be reflected by a higher resistance level for tranquilized than for nondrugged patients. Hence, the three patients on Marsilid were dropped from the drugged group along with three randomly chosen nondrugged patients. The subjects had been so chosen that it was possible to obtain balance or conservative bias with respect to the following characteristics; sex, race, diagnostic category, and manifest agitation (see Fig. 1).

The data were converted to log conductance units in order to approximate a normal distribution. An analysis of variance was made over drug categories for

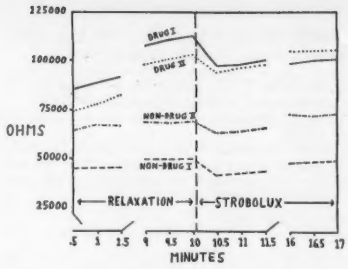

Fig. 1. Average BSR on drugged and nondrugged groups for sessions one and two.

the initial resting period and over session number. Interaction and session number were not significant. Drug versus nondrug achieved an F of 9.63 ($p < .01$). A breakdown of this F by two t-tests, one for the first session which was significant at better than the 1-percent level and one for the second session which was not significant, suggested a further influence of anticipatory effects.

The three nondrugged patients were reincluded, and two exploratory hypotheses were tested *a posteriori*. It was found (i) that the change in initial resting level from session one to session two did not differ significantly for drugged or nondrugged groups, and (ii) that the change in BSR over the entire relaxation period was significantly different ($p < .05$) between drugged and nondrugged groups, the former showing a greater increase in BSR.

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28 July 1958

Effect of Chlorpromazine on Salmonella enteritidis Infection in Mice

Abstract. Chlorpromazine increases the susceptibility of mice to infection with *Salmonella enteritidis*.

Goldman reports that infections are numerically among the most frequently encountered complicating factors in the institutional use of chlorpromazine and reserpine (*1*). He states that it is not believed that increased susceptibility to infections is a specific effect of these drugs. Experimental work with different species of animals and different pathogenic organisms has not led to consistent conclusions (*2, 3*). The following experiment was designed to study in a strain of mice the interaction between various dosages of chlorpromazine and the susceptibility to varying inocula of a virulent organism.

One hundred mice (Black Jax BAF 1 strain) of average weight 21.5 g were divided into ten groups of ten mice each. Chlorpromazine was administered subcutaneously in dosages ranging from 0 to 0.3 mg daily. Inocula of *S. enteritidis* in trypticase soy broth containing 0, 2000, 6000, and 14,000 organisms were administered intraperitoneally 24 hours after the first injection of chlorpromazine. The control groups, identically inoculated, were given daily subcutaneous injections of sterile water, and the noninfected, tranquilized control group received an intraperitoneal inoculation of sterile trypticase soy broth. Thus, as is shown in Table 1, the three groups of mice inoculated with 2000 organisms received 0, 0.2, and 0.3 mg of chlorpromazine, the four groups infected with 6000 organisms received 0, 0.1, 0.2, and 0.3 mg of chlorpromazine, and the two groups infected with 14,000 organisms received 0 and 0.1 mg of chlorpromazine a day, respectively. The noninfected control group received the highest dosage of chlorpromazine (0.3 mg) used in the experiment. The mice were allowed to eat and drink ad libitum, and no difference in the intake of food or water was noted between the various groups on chlorpromazine medication.

The effect of chlorpromazine on susceptibility to infection was evaluated in terms of the average number of days survived by mice in each group at the termination of the experiment—that is, 16 days after infection with *S. enteritidis*. After the 16th day no more injections were administered, although the mice continued to be observed for another 14 days, during which period no further deaths occurred in any of the groups. It was hypothesized that, should chlorpromazine be an adverse factor in the survival of the infected animals, the shortest average periods of survival would be manifest in the most heavily medicated group of the infected animals, and that the longest average periods of survival would be in the four control groups consisting of tranquilized, noninfected and nontranquilized, infected animals.

From the results summarized in Table 1, one can state that: (i) in the group given the highest dosage of chlorpromazine used, but no *S. enteritidis*, all survived the full 16-day period; (ii) for each level of *S. enteritidis* inoculation, increased daily chlorpromazine dosage shortened the average length of survival; (iii) at least for the two higher levels of daily chlorpromazine dosage, an increased quantity of *S. enteritidis* tended to shorten the average length of survival. The loading of survivors to the mean survival times can be estimated by consulting Table 2, which presents the frequency of survivorship for the same groups of mice.

Table 1. Effect of chlorpromazine on the average number of days (over a 16-day period) survived by mice following infection with *S. enteritidis*.

Chlorpromazine (mg/day)	Survival after infection (days)			
	No. of organisms			
	None	2000	6000	14,000
None		13.3	14.0	13.2
0.1			10.0	10.6
0.2		12.6	8.8	
0.3	16.0	10.0	8.5	

Table 2. Frequency of survivorship in numbers of mice which survived in each group of ten mice at the end of 30 days after infection with *S. enteritidis*.

Chlorpromazine (mg/day)	Frequency of survivorship			
	No. of organisms			
	None	2000	6000	14,000
None		6	8	5
0.1			3	3
0.2		4	2	
0.3	10	2	3	

An analysis of variance was performed on the days-of-survival data to test whether the differences observed might reasonably be attributed to chance. This resulted in an F value of 3.62, which, on 9 and 86 degrees of freedom, is significant at the .001 level (the estimated error variance was 16.7). The validity of the F-test is questionable, however, since the days-of-survival variable, by its very nature, tends to violate the assumption of similar group variances. (The group receiving no *S. enteritidis*, for example, has zero variance.) To avoid this objection, the days of survival recordings were ranked in order of magnitude, from 1 to 96, tied values being given the mean of the ranks tied for, and the Kruskal-Wallis H-test was performed on the resulting rank data (*4*). This yielded H of 27.09 which, treated as approximately chi-square with 9 degrees of freedom, is significant at the .005 level. Thus by either test there is little doubt that the differences observed in Table 1 reflect real differences attributable to the effects of the treatment combinations used. The survival data shown in Table 2 support this conclusion.

The mechanism for these observed actions of chlorpromazine is not clear. Blood cultures which were taken from the various groups of mice during the experiments showed an earlier onset as well as a more prolonged *S. enteritidis* bacteremia in the infected mice which were on chlorpromazine medication. A similar finding was reported by Maral and Cosar (*3*) in their work on tranquilized rabbits inoculated with pneumococci. Although this suggests some interference with the immune response of the organism, no individual factor can be singled out as the determining one. The reported effects of chlorpromazine medication include such findings as impairment in the function of the reticuloendothelial system (*5*) and depression of the phagocytic action of leukocytes (*6*). Whether analogous effects are obtained in the human being is unknown. However, at least one study has been reported in which the titer of antibodies to a hemolytic streptococcus was found to be significantly lower in patients on chlorpromazine medication than in a comparable nontranquilized group of patients (*7*, *8*).

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19 January 1959

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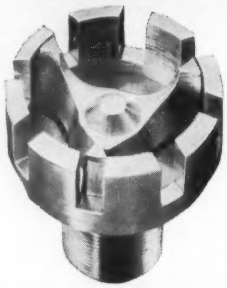

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Letters

(*Continued from page 746*)

The first comment by Donald Ross Green is meaningless because I did not make the statements or accusations he is refuting. My argument was directed toward getting rid of the arbitrary regulations—not the educationists themselves and their courses. Even Green concedes farther on in his letter that almost all educationists he knows "agree that certification requirements are sometimes arbitrary, rigid, and excessive." Toward the end he refers to the body of knowledge resulting from study and research in the past 50 years, but what is he concerned about? Surely sound scholarly education courses based on that research and knowledge would survive on merit without artificial support by excessive and arbitrary legal requirements.

I stated essentially that most great teachers of the past and present never had any courses in an education department. Green states that "most of our finest contemporary teachers have taken education courses." Ignoring a possible quibble over the word *most,* both statements are correct, but taken together they lead to the conclusion that education courses are not vital to the making of good science teachers; they may help and often do help, but their contribution is auxiliary and not dominant. The trouble is that an important segment of educationists won't play the auxiliary role of helping educated people to teach others. They insist on dominating the whole stage. They are appalled at the suggestion that the experts in the field of science should have an important voice in deciding who shall teach science.

My statement that capable teachers are barred from public schools by present requirements ignored provisional certification. So granted: the superior scholar and teacher is not technically barred but may teach provisionally. This only proves that under present law in most states the President's science adviser can get provisional certification—the provision being, of course, that he bone up at night and in the summer in the education department until his "deficiencies" are made up! It is still a sorry situation that merely emphasizes the importance of reducing excessive requirements. To meet the requirement in education courses is hard for the student who considers teaching late in his academic career. He is in a jam for time. The graduate student likewise is out of luck. He looks at the "provisions" of the provisional certificate and decides to do something else; he is, in effect, barred from teaching in the public schools.

These ridiculous situations could be solved through legislation recognizing science-department certification as acceptable in lieu of the standard education-department requirements. A science-department faculty is made up of capable, conscientious people who can accept responsibility. After working with a student for several years, they know his capabilities and needs. If he needs the presently required education courses, they will make him take them, but if not, they won't waste his time, and he will be a better teacher for it. Science faculty members *are* professional teachers as well as scholars.

Of course Green is right in believing that on intellectual grounds there is enough agreement so that all could work together. But, unfortunately, many educationists lack the sincere constructive attitude which is evident in Green's letter. Power-hungry, they resist any interference with their present almost complete control of secondary education. I'm afraid the answer lies in political action by a public awakened by sputnik to the existence of the problem and gradually becoming aware of the causes. Conference amounts to an intellectual Munich. From a position securely entrenched in law the educationists negotiate against the educated community armed with an umbrella.

It is all very well to know where to find props for demonstrations, how to use film libraries, and how to locate audio-visual materials, but the science faculty is a better judge of how much education-department time is necessary for picking up these incidentals than those who lobbied the present rigid and arbitrary requirements onto the statute books years ago or the present-day educationists who resist change of those old-fashioned laws.

I didn't whitewash the liberal arts departments. If there are places where rescheduling is necessary to meet the needs of the teaching profession, then by all means let's have rescheduling.

The attempt by Webb to restate my premise as merely a complaint that "a college graduate with a major in science cannot begin to teach at once" indicates inability to refute my argument for repeal of present laws under which that same graduate still cannot teach in the public schools after adding a Ph.D. and ten years of successful teaching in universities or private secondary schools. The new graduate with one more year and enough education-department courses can teach at once—he can get the certification that is denied the superior scholar and experienced professional teacher. Teaching quality is thus downgraded by applicable but obsolete regulations. Laws that create such inequities should be repealed or drastically revised.

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Meetings

Unusual Conditions in the Pacific

During 1957 and early 1958 it became apparent that the weather, temperatures, and biology of the Pacific were undergoing changes that were quite outside the range of conditions of the last decade or more.

At the invitation of the Scripps Institution of Oceanography, 30 scientists met at Rancho Santa Fe, near San Diego, California, 2–4 June 1958, to consider the nature and causes of the unusual conditions (*1*).

Participants were from institutions on both coasts of North America and from Hawaii, Japan, and Peru, representing research in the fields of meteorology, oceanography, marine biology, and fishery biology, and included persons actively pursuing their research in the Pacific, from the Bering Sea to Peru and westward through the Central Pacific to Japan.

Data considered were the Northern Hemispheric circulation in the atmosphere, sea temperatures, sea level and currents of the Pacific, and the distribution of marine organisms. In addition, the symposium heard a report on the unusual solar events of 1957, when, in September, sun-spot activity reached a 250-year (all-time record) high. The possible relation to the unusual meteorology was discussed.

Another major departure from conditions in immediately preceding years and from those recorded over long-term periods consisted of the unusually strong development and the southeasterly position of the Aleutian low-pressure systems, especially during the winter of 1957–58; these changes produced markedly anomalous wind fields in middle latitudes of the eastern Pacific directed northeastward, and in the northwest Pacific directed southwestward. This was accompanied by unusually high sea temperatures over much of the eastern Pacific, from the Gulf of Alaska to the coasts of Peru. On the other hand, colder sea temperatures extended southward from the Bering Sea along the coast of Japan. Hawaii, during the summer of 1957, failed to experience the usual lowering of salinity connected with the seasonal oscillations of the subtropic convergence system. Sea levels were anomalously high along the West Coast of North America, by an average of 0.5 foot, with the anomaly appearing earliest and most pronouncedly along the coast of southern California. Drift bottles released 500 miles off the coast of British Columbia at latitude 50°N fetched up on beaches rimming the northern shore of the Gulf of Alaska instead of taking their more usual course eastward toward

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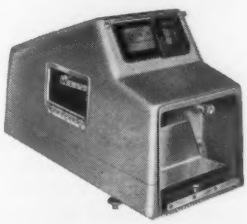

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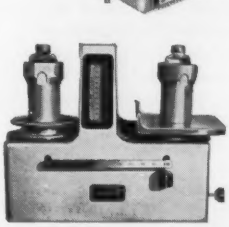

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British Columbia, Washington, and Oregon. A strongly developed coastal countercurrent along central and northern California, Oregon, and Washington was evidenced by drift bottles released in California waters.

The diatom and dinoflagellate flora monitored at the Scripps Pier at La Jolla, California, included considerable numbers of tropical forms previously rare or absent. Southern forms also were found far north of their expected range in California waters. Certain species of salps ordinarily confined to waters off southern California extended northward in coastal waters well beyond Point Conception, as did also certain euphausiids of similar normal range. Species of these two groups, which normally occupy the oceanic mid-Pacific waters, apparently did not spread eastward towards the North American coasts, however. As for the fishes, there were a number of records from farther north of tropical and subtropical species, and two species, the barracuda and yellowtail, usually caught by sportsmen in moderate numbers off southern California, were taken in numbers larger by an order of magnitude than the usual number. Dolphin fish were taken in entirely unprecedented numbers. Sardine spawning, which in the preceding 7-year period had been largely confined to waters off Lower California, in 1957 and 1958 took place in southern California waters. There was an indication that, in 1958, the pelagic phyllosome larvae of the spiny lobster were being better retained in the waters of southern California than in previous years.

The long-term records of such meteorological and oceanographic data as have been recorded systematically suggested that the conditions of 1957 and the winter of 1957–58 represented a marked reversal of conditions which had persisted during the previous decade and resembled roughly the conditions usual during the decade of the 1930's. The year 1958 appeared, at the time of this writing, to resemble the unusual years of 1926, 1931, and 1941.

Extensive consideration of theoretical models and empirical oceanographic observations led to the conclusion that the phenomena observed during 1957, which reached their peak in the winter of 1957–58, were undoubtedly the evidence of large-scale advection of water masses, but that the theory and the data so far analyzed are inadequate to distinguish the processes by which this advection took place. Particularly in question was the relative influence of transport from the offshore direction as compared with the transport alongshore from the south. The coastal countercurrent (sometimes called the Davidson Current) was more highly developed than in the immediately preceding years, but the mechanisms involved, and the role the coastal countercurrent played in the changed temperature field, remained obscure. Likewise, speculation on a possible displacement of the zonal North Pacific current system failed to produce an entirely satisfactory explanation.

In view of the obviously inadequate state of oceanographic observations and theory, it was felt that the conditions of 1957 and of the winter of 1957–58 should furnish strong motivation for determined efforts to evolve theories in conjunction with direct measurements of water movements and continued dynamic measurements on a much wider scale.

The symposium emphasized the point that local changes of conditions cannot be studied provincially but are part of Pacific-wide or possibly world-wide changes.

The proceedings of the symposium are to be published, and are to be dedicated to Bell Shimada and Townsend Cromwell, whose tragic and untimely deaths in an aircraft accident in Mexico occurred during the symposium.

JOHN D. ISAACS
Scripps Institution of Oceanography, La Jolla, California

OSCAR E. SETTE
Fish and Wildlife Service, U.S. Department of the Interior, Stanford, California

Note

1. This report is a contribution from the Scripps Institution of Oceanography. It is based on a report to the American Society of Limnology and Oceanography, Logan, Utah, of 18 June 1958.

Forthcoming Events

May

18–22. American Soc. of Tool Engineers, 27th annual, Milwaukee, Wis. (ASTE, 10700 Puritan, Detroit 38, Mich.)

19–23. Oil and Gas Power Conf. (American Soc. of Mechanical Engineers), Houston, Tex. (O. B. Schier, ASME, 29 W. 39 St., New York 18.)

19–24. American Pharmaceutical Assoc., annual conv., Cincinnati, Ohio. (R. P. Fischelis, APA, 2215 Constitution Ave., Washington 7.)

20–21. Analog and Digital Instrumentation, 3rd natl. conf. (American Inst. of Electrical Engineers), Philadelphia, Pa. (N. S. Hibshman, AIEE, 33 West 39 St., New York 18.)

20–22. American Oil Chemists' Soc., spring, 50th anniversary, New Orleans, La. (Mrs. L. R. Hawkins, 35 E. Wacker Dr., Chicago 1, Ill.)

20–22. Boundary Problems in Differential Equations, symp., Madison, Wis. (R. E. Langer, Mathematics Research Center, U.S. Army, 1118 W. Johnson St., Madison 6.)

20–23. American Urological Assoc., Atlantic City, N.J. (S. L. Raines, 188 S. Bellevue Blvd., Memphis, Tenn.)

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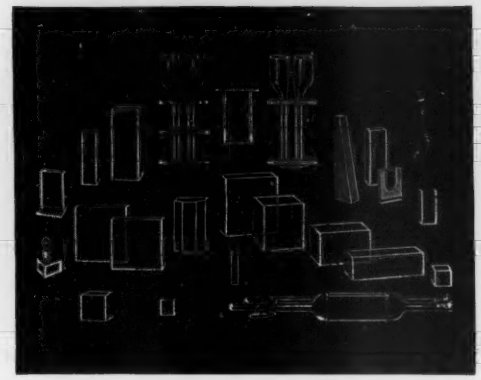

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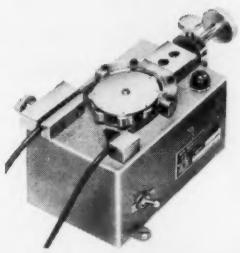

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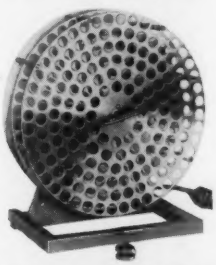

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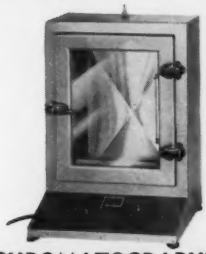

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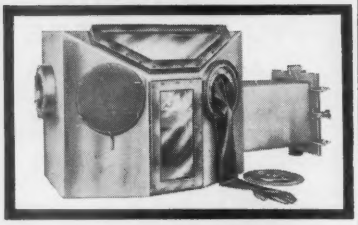

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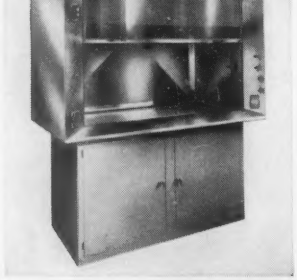

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20–23. International Anesthesia Research Soc., 33rd cong., Miami Beach, Fla. (A. W. Friend, IARS, E. 107 and Park Lane, Cleveland 6, Ohio.)

20–24. American College of Physicians, Chicago, Ill. (E. R. Loveland, 4200 Pine St. Philadelphia 4, Pa.)

20–26. International Acad. of Pathology, annual, Boston, Mass. (F. K. Mostofi, Armed Forces Inst. of Pathology, Washington 25.)

21–22. Electronic Data Processing, conf., Cincinnati, Ohio. (C. H. Osterbrock, IRE, Univ. of Cincinnati, Cincinnati, Ohio.)

21–23. American Assoc. for Thoracic Surgery, Los Angeles, Calif. (H. T. Langston, 7730 Carondelet Ave., St. Louis 5, Mo.)

21–23. German Starch Conv., Detmold, West Germany. (Assoc. of Cereal Research, Detmold, Am Schutzenberg 9, West Germany.)

21–25. Psychosomatic Research, 4th European cong., Hamburg, Germany. (H. Freyberger, II. Med. Univ.–Klinik und Poliklinik, Hamburg-Eppendorf, Germany.)

23–24. Molecular Genetics and Human Disease, symp., Syracuse, N.Y. (L. I. Gardner, Dept. of Pediatrics, State Univ. of New York, College of Medicine, Syracuse 10.)

23–25. American Assoc. of Pathologists and Bacteriologists, Boston, Mass. (R. L. Holman, 1542 Tulane Ave., New Orleans 12, La.)

23–25. Hawaii Medical Assoc., Hilo. (L. McCaslin, 510 S. Beretania St., Honolulu 13.)

23–25. Nuclear Reactor Theory; Finite Groups, 2 symps. by Amer. Mathematical Soc., New York, N.Y. (E. G. Begle, Leet Oliver Hall, Yale Univ., New Haven, Conn).

24. Illinois State Acad. of Science, 52nd annual, Chicago. (J. S. Ayars, Department of Registration and Education, State Natural History Survey Division, Urbana, Ill.)

24–25. American Assoc. of University Professors, Pittsburgh, Pa. (R. F. Fuchs, AAUP, 1785 Massachusetts Ave., NW, Washington 6.)

24–25. Georgia Acad. of Sciences, Macon. (R. J. Martin, Dept. of Geology, Emory Univ., Atlanta 22, Ga.)

24–25. Louisiana Acad. of Sciences, Ruston. (G. H. Ware, Northwestern State College, Natchitoches, La.)

24–25. South Dakota Acad. of Science, Yankton. (J. M. Winter, Botany Dept. State Univ. of South Dakota, Vermillion, S.D.)

25. West Virginia Acad. of Sciences, Huntington. (J. D. Draper, Bethany College, Bethany, W.Va.)

25–26. Population Assoc. of America, Providence, R.I. (D. O. Price, Box 630, Chapel Hill, N.C.)

25–30. Scientific Apparatus Makers Assoc., 41st annual, White Sulphur Springs, W. Va. (J. Irving, Director of Public Information, SAMA, 20 N. Wacker Drive, Chicago 6, Ill.)

25–1. Industrial Health Conf., Chicago, Ill. (Industrial Health Conf., Room 1313, 28 E. Jackson Blvd., Chicago 4.)

26–29. Industrial Medical Assoc., Chi-

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27–28. Society of Exploration Geophysicists, 12th annual midwestern exploration, El Paso, Tex. (D. Dawson, Dawson Geophysical Co., Midland, Tex.)

27–28. Society of Neurological Surgeons, New York, N.Y. (B. S. Ray, 525 E. 68 St., New York 21.)

27–29. Aero Medical Assoc., Los Angeles, Calif. (T. H. Sutherland, P.O. Box 26, Marion, Ohio.)

27–30. Physical Chemistry of Extractive Metallurgy, intern. symp., Pittsburgh, Pa. (AIME, 29 W. 39 St., New York 18, N.Y.)

27–30. Physical Chemistry of Process Metallurgy, intern. symp., Pittsburgh, Pa. (J. F. Elliott, Room 8-109, Massachusetts Inst. of Technology, Cambridge 39.)

27–1. American Psychiatric Assoc., Philadelphia, Pa. (C. H. Hardin Branch, 156 Westminister Ave., Salt Lake City, Utah.)

29–1. American Inst. of Electrical Engineers, Syracuse, N.Y. (N. S. Hibshman, AIEE, 33 W. 39th St., New York 18.)

30–1. Eastern States Health Education Conf., New York, N.Y. (I. Galdston, New York Acad. of Medicine, 2 E. 103 St., New York 29.)

30–1. Youth Conference on the Atom, 1st natl., Atlantic City, N.J. (W. Adams, Bozell & Jacobs, Inc., 2 W. 45 St., New York 36.)

30–2. American Assoc. for Cleft Palate Rehabilitation, Philadelphia, Pa. (D. C. Spriestersbach, University Hospitals, Iowa City, Iowa.)

30–2. American Goiter Assoc., Chicago, Ill. (J. C. McClintock, 149½ Washington Ave., Albany, N.Y.)

30–2. American Physical Soc., Washington, D.C. (K. K. Darrow, Columbia Univ., New York 27, N.Y.)

30–2. Eastern College Science Conf., 13th annual, Boston, Mass. (A. F. Lett, ECSC, Suffolk Univ., Boston 14.)

30–2. Kansas Acad. of Sciences, Lawrence. (J. O. Harris, Kansas State College, Manhattan.)

30–3. Student American Medical Assoc., Chicago, Ill. (R. F. Staudacher, 430 N. Michigan, Chicago 11.)

30–4. American Assoc. for the Study of Neoplastic Diseases, Gatlinburg, Tenn. (B. H. Sisler, Box 268, Gatlinburg.)

May

1–3. Prevention of Bacterial Resistance to Antibiotics, intern. symp., Perugia, Italy. (Segreteria del Simposio, Clinica Ostetrica e Ginecologica, Policlinico, Perugia.)

2. Idaho Acad. of Science, Moscow. (E. J. Larrison, Sec.-Treas., Dept. of Biological Sciences, Univ. of Idaho, Moscow.)

2–3. American Psychosomatic Soc., 16th annual, Atlantic City, N.J. (M. Rosenbaum, APS, 265 Nassau Rd., Roosevelt, N.Y.)

2–7. Experimental Biology, intern. symp. (celebration of Lazzaro Spallanzani), Reggio and Pavia, Italy. (C. Jucci, Director, Istituti di Zoologia L. Spallanzani, Universita-Pavia, Palazzo Botta, Pavia, Italy.)

2–9. International Union for Health Education of the Public, 4th conf., Dussel-

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3. American Federation for Clinical Research, annual, Atlantic City, N.J. (G. E. Schreiner, Georgetown Univ. Medical Center, Washington 7.)

3. Periapical Lesions-Pacific Coast Oral Pathology Workshop, 1st annual, Los Angeles, Calif. (W. Bullock, Dept. of Pathology, Univ. of Southern California School of Medicine, 1200 N. State St., Los Angeles.)

3–7. American Assoc. of Cereal Chemists, 44th annual, Washington, D.C. (J. W. Pence, AACC, Western Utilization Research Laboratories, Albany, Calif.)

3–7. Electrochemical Soc., Philadelphia, Pa. (Electrochemical Soc., Inc., 216 W. 102 St., New York 25.)

3–7. Electrode Processes, symp., Philadelphia, Pa. (Headquarters, Air Force Office of Scientific Research, Washington 25.)

3–7. Mechanical Properties of Intermetallic Compounds, Philadelphia, Pa. (J. H. Westbrook, General Electric Research Laboratory, P.O. Box 1088, Schenectady, N.Y.)

4. American Soc. for Clinical Investigation, annual, Atlantic City, N.J. (W. W. Stead, J. Hillis Miller Health Center, Gainesville, Fla.)

4–5. Microcirculatory Conf., 7th annual meeting, NIH, Bethesda, Md. (B. W. Zweifach, 550 First Ave., New York 16.)

4–7. American Geophysical Union, annual, Washington, D.C. (W. E. Smith, AGU, 1515 Massachusetts Ave., NW, Washington 5.)

4–7. National Instrumentation Flight Test Symp., 5th, Seattle, Wash. (H. T. Noble, Boeing Airplane Co., Flight Test Station, Wichita 1, Kan.)

4–8. American Soc. of Civil Engineers, Cleveland, Ohio. (W. H. Wisely, 33 West 39th St., New York 18.)

5–6. Association of American Physicians, annual, Atlantic City, N.J. (W. W. Stead, vice president, AFCR, J. Hillis Miller Health Center, Gainesville, Fla.)

5–6. Self-Organizing Systems, conf., Chicago, Ill. (S. Cameron, ICSOS Conference Secretary, Armour Research Foundation, 10 W. 35 St., Chicago 16.)

5–7. International Scientific Radio Union, spring meeting, Washington, D.C. (J. P. Hagen, National Acad. of Sciences, 2101 Constitution Ave., NW, Washington 25.)

5–9. Southwestern and Rocky Mountain Div., AAAS, Laramie, Wyo. (M. G. Anderson, New Mexico College of Agriculture and Mining, State College.)

5–12. Electronic Distance Measuring Equipment, Intern. Assoc. of Geodesy symp., Washington, D.C. (C. A. Whitten, Coast & Geodetic Survey, Washington 25.)

6–8. American Inst. of Chemists, Atlantic City, N.J. (L. Van Doren, American Inst. of Chemists, Inc., 60 E. 42 St., New York 17.)

6–8. American Pediatric Soc., Buck Hill Falls, Pa. (A. C. McGuinness, 2800 Quebec St., Washington 8.)

6–9. National Science Fair, 10th, Hartford Conn. (Science Clubs of America, 1719 N St., NW, Washington 6.)

6–10. Infectious Pathology, intern. cong., Milan, Italy. (A. Janussi, Secretary General, via Boccaccio 25, Milan.)

7–9. Midwestern Psychological Assoc., Chicago, Ill. (I. E. Farber, Dept. of Psychology, Univ. of Michigan, Ann Arbor.)

7–9. World Cong. on Agricultural Research, International Confederation of Agricultural Engineers and Technicians, Rome, Italy. (CITA, Regional Secretariat, 86, via Barberini, Rome.)

8–10. Uranium, 4th annual symp., Moab, Utah. (AIME, 29 W. 39 St., New York 18.)

9–11. International Soc. of Acupuncture, 10th cong., Paris, France. (SIA, 8 avenue Franklin Roosevelt, Paris 8e.)

10–15. Society of American Bacteriologists, St. Louis, Mo. (E. M. Foster, Univ. of Wisconsin, Madison 6.)

10–14. American Soc. of Maxillofacial Surgeons, Chicago, Ill. (O. H. Stuteville, 700 N. Michigan, Chicago 11.)

11–12. Practical Problems of Coordinating and Integrating All Services Related to the Treatment, Training and Management of the Mentally Retarded, conf., Vineland, N.J. (J. D. Eadline, Training School, Vineland, N.J.)

11–13. Instrumentation and Computation in Process Development and Plant Design, symp., London, England. (Institute of Chemical Engineers, 16, Belgrave Sq., London, S.W.1.)

11–13. Microwave Theory and Techniques, natl. symp., Boston, Mass. (H. Pratt, Inst. of Radio Engineers, 1 E. 79 St., New York 21.)

11–13. Power Instrumentation, natl. symp., Kansas City, Mo. (H. H. Johnson, Consolidated Edison Co. of New York,

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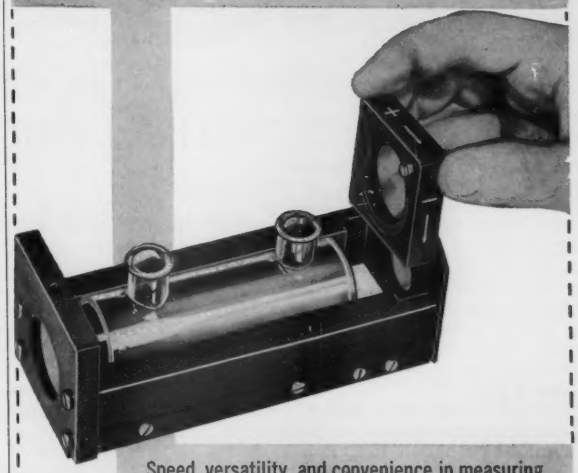

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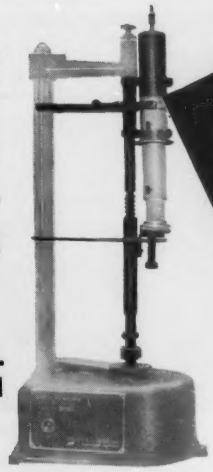

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13–16. Human Biochemical Genetics, Ciba Foundation symp., London England. (G. E. W. Wolstenholme, Ciba Foundation, 41 Portland Pl., London, W.1.)

14–15. Operations Research Soc. of America, Washington, D.C. (H. J. Miser, Rt. 2, Box 211, Vienna, Va.)

14–16. Acoustical Soc. of America, Ottawa, Canada. (W. Waterfall, 335 E. 45 St., New York 17.)

14–17. American Acad. of Dental Medicine, 13th annual, Atlantic City, N.J. (H. A. Lentz, 619 Main Ave., Passaic, N.J.)

14–16. American Assoc. of Physical Anthropologists, Madison, Wis. (E. E. Hunt, Jr., Peabody Museum, Harvard Univ., Cambridge 38, Mass.)

17–21. American Ceramic Soc., 61st annual, Chicago, Ill. (C. S. Pearce, ACS, 4055 N. High St., Columbus 14, Ohio.)

17–21. Institute of Food Technologists, 19th annual, Philadelphia, Pa. (C. S. Lawrence, IFT, 176 W. Adams St., Chicago 3, Ill.)

17–23. Antibiotics, intern. symp., Prague, Czechoslovakia. (M. Heřmanský, Antibiotics Research Inst., Roztoky near Prague, Czechoslovakia.)

17–23. Mass Spectrometry, 7th, Los Angeles, Calif. (A. G. Sharkey, Jr., U.S. Bureau of Mines, 4800 Forbes Ave., Pittsburgh 13, Pa.)

18–20. Instrumentation Methods of Analysis, 5th natl. symp., Houston, Tex. (H. S. Kindler, Director of Technical and Educational Services, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.)

19–23. American Assoc. of Mental Deficiency, Milwaukee, Wis. (N. A. Dayton, Mansfield State Training School & Hospital, Mansfield Depot, Conn.)

20–22. Education of the Scientist in a Free Society, conf., Milwaukee, Wis. (A. B. Drought, College of Engineering, Marquette Univ., 1515 W. Wisconsin Ave., Milwaukee 3.)

21–23. American Assoc. for the History of Medicine, 32nd annual, Cleveland, Ohio. (Miss E. H. Thomson, Yale Univ. School of Medicine, New Haven, Conn.)

21–27. Veterinary Cong., 16th intern., Madrid, Spain. (J. Jensen, General Secretary of Permanent Committee, Belstraat 168, Utrecht, Netherlands; or W. A. Hagan, Dean, Cornell Univ., New York State Veterinary College, Ithaca, N.Y.)

24–29. National Tuberculosis Assoc., Chicago, Ill. (Mrs. W. B. White, 1790 Broadway, New York 19.)

24–29. Social Welfare, natl. conf. and annual forum, San Francisco, Calif. (National Conference on Social Welfare, 22 W. Gay St., Columbus 15, Ohio.)

25–27. American Gynecological Soc., Hot Springs, Va. (A. A. Marchetti, 3800 Reservoir Rd., NW, Washington 7.)

25–27. American Soc. for Quality Control, Cleveland, Ohio. (L. S. Eichelberger, A. O. Smith Corp., Milwaukee, Wis.)

25–27. Chemical Inst. of Canada, 42nd annual conf., Halifax, Nova Scotia. (Chemical Inst. of Canada, 18 Rideau St., Ottawa, Ontario, Canada.)

25–27. Telemetering, natl. conf., Denver, Colo. (R. Schmidt, AVCO Mfg. Co., 201 Lowell St., Wilmington, Mass.)

25–28. Smoking and Lung Cancer, and Pulmonary Emphysema, symps., American Trudeau Soc., Chicago, Ill. (H. W. Harris, Medical Sessions Committee, ATS, 1790 Broadway, New York 19.)

25–29. American College of Cardiology, 8th annual, Philadelphia, Pa. (P. Reichert, ACC, Empire State Bldg., New York 1.)

25–29. Transistors and Associated Semi-Conductor Devices, intern. conv., London, England. (Institution of Electrical Engineers, Savoy Pl., London, W.C.2.)

25–31. Electroheat, 4th intern. cong., Stresa, Italy. (International Union for Electroheat, 14, rue de Stäel, Paris 15e.

28–30. American Ophthalmological Soc., Hot Springs, Va. (M. C. Wheeler, 30 W. 59 St., New York 19.)

29–30. International Assoc. for Bronchology, 9th cong., Madrid, Spain. (J. Abello, IAB, Lagascar 13, Spain.)

30–5. Applications of Atomic Energy to the Petroleum Industry, symp., 5th World Petroleum Congress, New York, N.Y. (C. E. Davis, General Secretary, 5th World Petroleum Congress, 527 Madison Ave., New York 22.)

31–3. Special Libraries Assoc., 50th annual conv., Atlantic City, N.J. (Miss M. E. Lucius, 31 E. 10 St., New York 3.)

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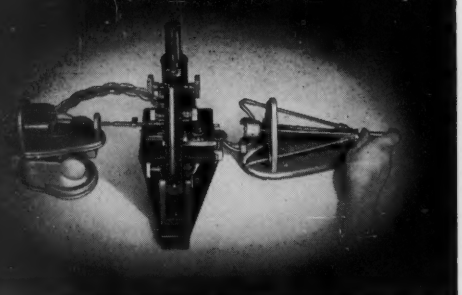

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■ METERING PUMPS handle flows from 0.65 to 13.10 gal/hr at a maximum pressure of 1000 lb/in². A screw adjustment on a driving crank adjusts the stroke while the pump is stopped. Accuracy is ± 1 percent when the pump is operated between 10 and 100 percent of stroke length. Parts in contact with corrosive liquids may be machined of Hastalloy alloys. (American Meter Company, Dept. 674)

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■ DIGITAL VOLTMETER adds a fifth digit to the manufacturer's previous four-digit model. The instrument thus achieves accuracy of ± 0.01 percent ± 1 digit in four automatic ranges from 0.0001 to 1000.0 v d-c without loss of accuracy in the transition between ranges. (Kintel Division, Cohu Electronics, Dept. 698)

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(*Continued on page 798*)

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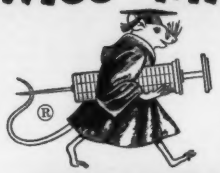

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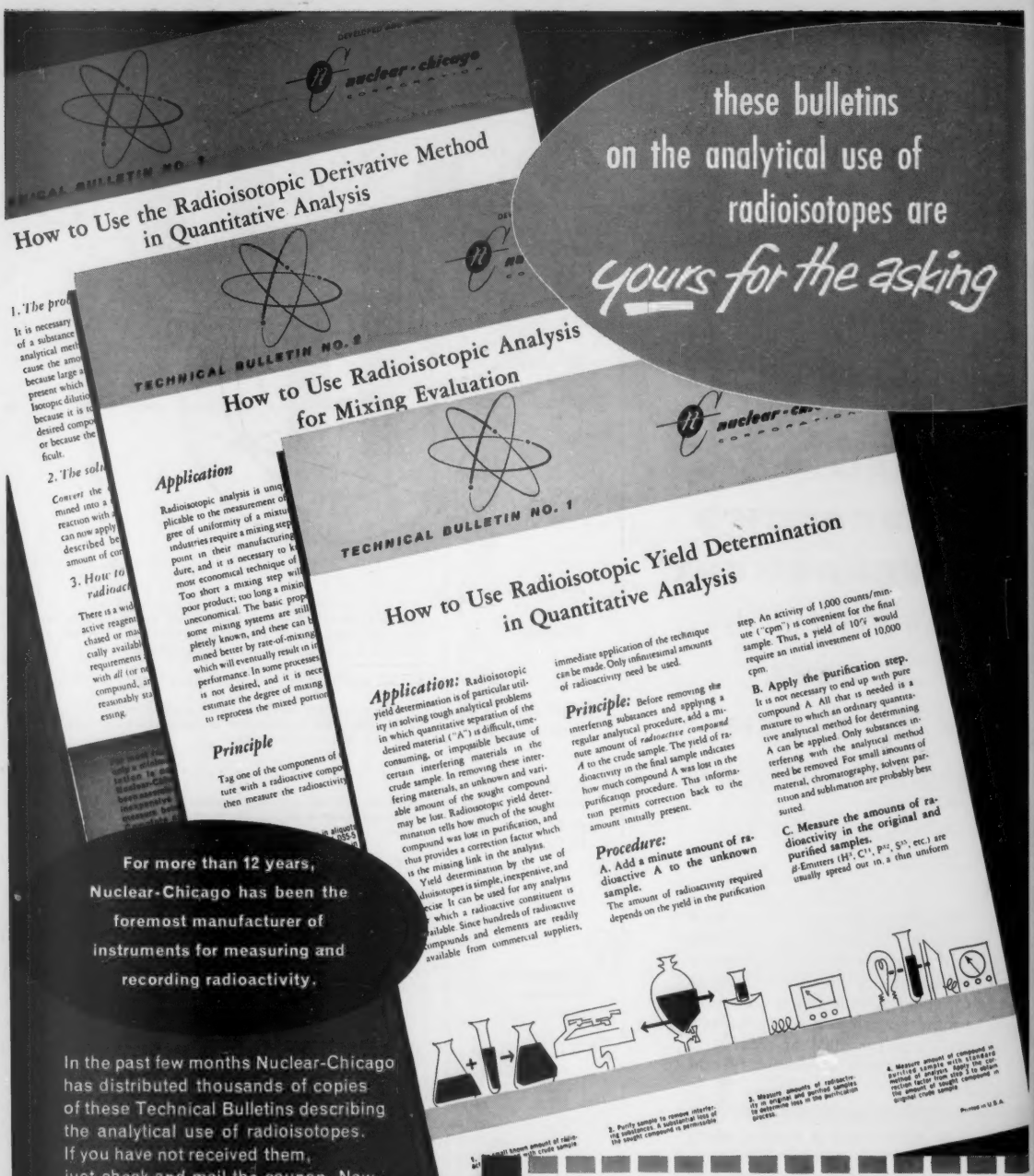
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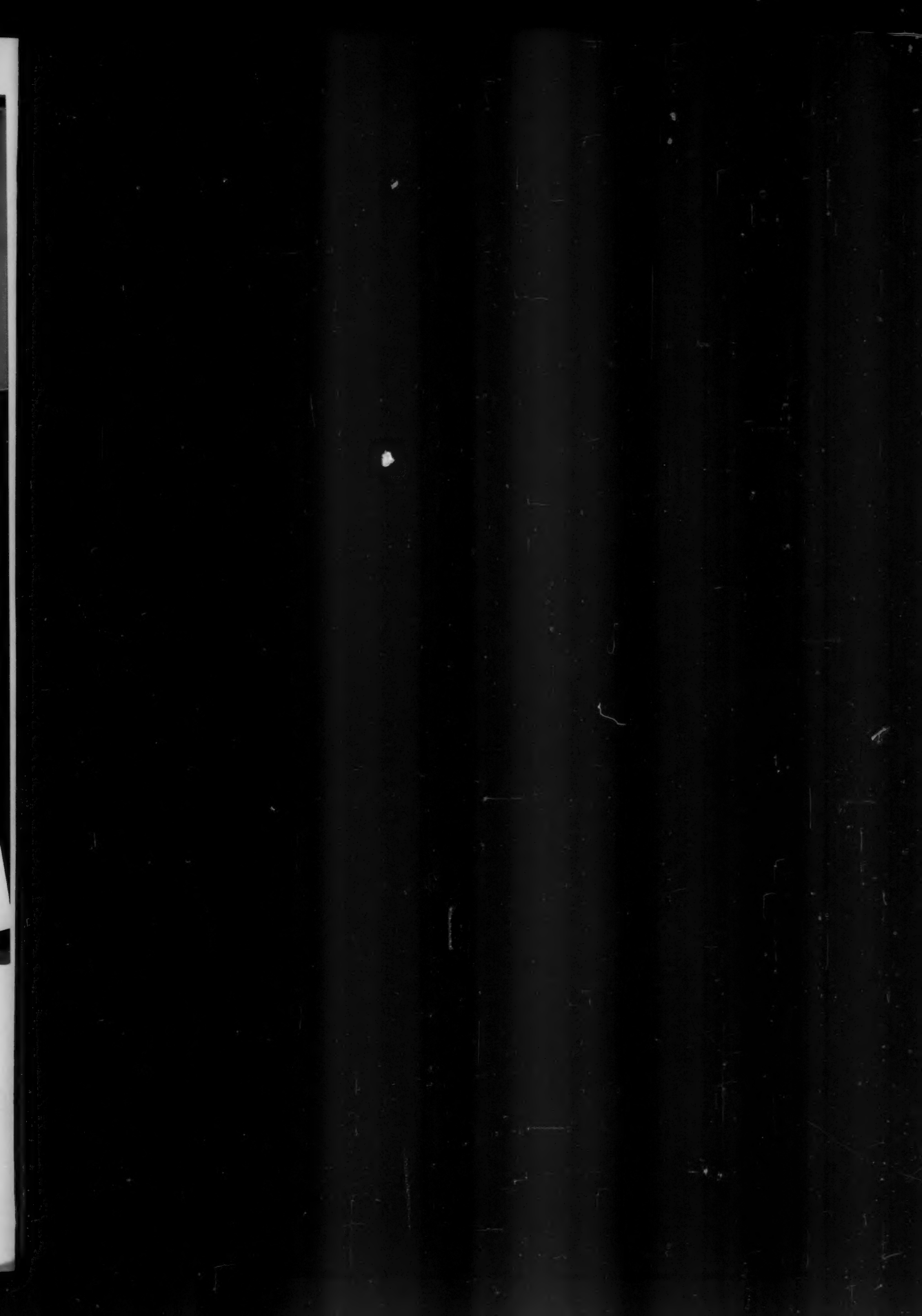
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